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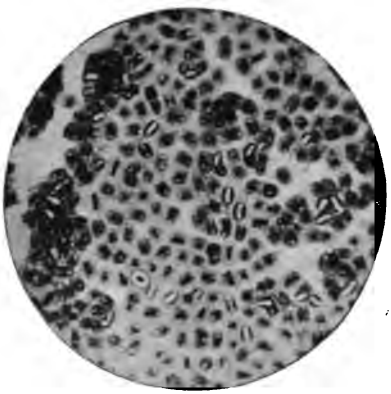

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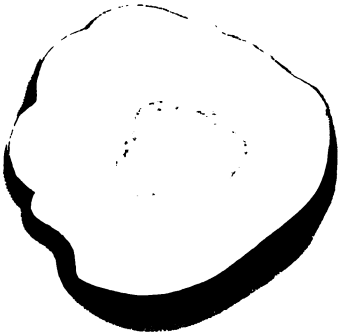

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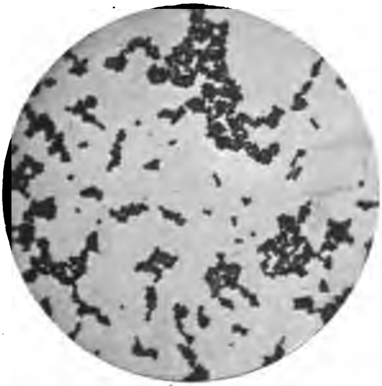

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1. Yeast-germs from lager beer. 2. Zoögloea. 3. Culture of staphylococcus pyogenes citreus on potato. 4. [illegible] yogenes aureus, from an agar culture. 5. Streptococcus pyogenes, from phlegm[illegible]

Saunders' New Aid Series

A MANUAL OF

THE MODERN THEORY AND TECHNIQUE OF

SURGICAL ASEPSIS

BY

CARL BECK, M.D.,

VISITING SURGEON TO ST. MARK'S HOSPITAL AND TO THE GERMAN POLIKLINIK OF NEW YORK CITY, ETC.

WITH 65 ILLUSTRATIONS IN THE TEXT, AND 12 FULL-PAGE PLATES

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TO THE MEMORY

OF

BERNHARD VON LANGENBECK,

THE GREAT SURGEON AND PHILANTHROPIST.

PREFACE.

THIS Manual of Surgical Asepsis, which is based upon the method employed in my teaching upon the treatment of wounds at the New York Post-Graduate School and at St. Mark's Hospital, was written in compliance with the solicitations of those practitioners whom it has been my pleasure to instruct at these institutions.

As it is only within a comparatively few years that bacteriology has revolutionized the practice of surgery, it is natural that even the most excellent surgical text-books lack full and detailed descriptions of the theory and technique of surgical asepsis.

While the leading idea has been to write a *practical* book that would in a measure meet the deficiency of the larger works on the subject, yet *theory* could not entirely be omitted, inasmuch as most of the technique of modern wound-treatment is founded upon experiments conducted in the laboratory. But only those experiments have been accentuated whose comprehension is indispensably associated with that of technique, and whose results can be corroborated by clinical observation. Hence in this treatise there has been followed a

plan somewhat different from that of my eminent predecessors, Schimmelbusch, Braatz, and Terrier.

Certain details which may seem unimportant upon superficial consideration, but the neglect of which is incompatible with surgical success, have been given more prominence than is ordinarily accorded them in their connection with the subject of asepsis—for instance, the descriptions of the technique of suturing and of disinfection, the dressings employed for the different regions of the body, the maintenance of asepsis in private practice, etc.

An important feature of this book, or at least so regarded by the writer, is that a stricter line of demarcation than usual is drawn between wounds aseptically performed by surgeons and those otherwise inflicted or those dependent upon inflammatory processes. In the latter category *antisepsis* asserts its prerogatives, but only as subordinate to asepsis. As an expression of the position thus assumed, were written the sections on Infected Wounds, on Open-wound Treatment, and on the Renewal of Dressings.

Among the antiseptic drugs, iodoform is assigned the most prominence, and in regarding its extensive employment by the profession its advantages and disadvantages are thoroughly discussed. The question of tuberculosis, that presents itself so frequently to practitioners, has also been exhaustively considered in its relation to asepsis. An entire section is devoted to anæsthesia, since, irre-

spective of its vital importance in most surgical procedures, its insufficient mastering is apt to impair seriously the aseptic condition of the patient.

In the preparation of this manual I have drawn liberally from the published labors of Billroth, Flügge, Gerster, Günther, Heim, Hüter, Keen, Koch, Prudden, Senn, Sternberg, Terrier, Tillmanns, Virchow, White, Winiwarter, Wyeth, and others, and especially have I gathered from the excellent books of Braatz and Schimmelbusch many valuable ideas on the modern conception of wound-treatment.

The plates and most of the illustrations are original, being reproductions of photographs taken of patients and of apparatus; the others were taken from the standard works of Billroth, Braatz, Heim, Schimmelbusch, Tillmanns, and Winiwarter, to each of which authors I desire to express my thanks for the ready consent to the use of the illustrations selected. Some of the representations of microbes were drawn from specimens which I prepared in the summer of 1894, during my stay at the Hygienic Institute of Berlin, under the supervision of my distinguished friend Dr. Erich Wernicke; the other specimens depicted were copied from Günther's *Bacteriology*.

I am deeply indebted to Profs. Von Bergmann and Czerny, and to Drs. Schede and Körte for the facilities afforded me to study the aseptic methods of their respective clinics. I would be derelict not to express my

gratitude also to Drs. Schlange, Schimmelbusch, Braatz, and Schmidt, who so materially aided further investigations of asepsis at the University clinics of Berlin and Heidelberg.

In conclusion I desire to thank Dr. F. C. Valentine for his most efficient assistance in revising the proofs, and Mr. John Vansant for the valuable labor he so cheerfully performed. My thanks are likewise due to Mr. W. B. Saunders for the typographical and pictorial excellence of the work.

CARL BECK.

37 E. 31st St., New York,
March, 1895.

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INTRODUCTION.

WITH the dawn of Antisepsis there burst upon the surgical world the beginning of a new light —a new era was given to surgery.

When a student in Berlin in 1876, the writer one day heard his revered teacher, Von Langenbeck, say: "A new method has been advanced by an English surgeon who predicates the principle of wound-treatment upon the destruction of organic germs, which he assumes to be the cause of wound disturbances. The excellent results claimed by him are not in accord with those we obtain, hence I can hardly grasp their perfection; yet, notwithstanding my experience, I feel it incumbent upon me to test them in practice." The old master, then reputed throughout the world as the father of joint-resection, did not hesitate to become practically the pupil of young Richard von Volkmann, chief of the Halle Surgical Clinic, who had just returned from London, having there studied the methods of Joseph Lister. Von Langenbeck was soon convinced that Listerism was not a phantasm.

The curse of centuries was ended. While,

before antisepsis, 80 per cent. of all wounds treated at the University Clinic at Munich were affected with hospital gangrene, this disease was now looked upon by the students as a rarity. Formerly, the mortality from amputations reached even 60 per cent.; thenceforth deaths directly traceable to amputations were the exception.

To the perspicacity of those "to the manor born," and to those who have made America their home, is due the powerful impetus given to the dissemination of this new surgical discovery. Arpad G. Gerster, in his excellent work, was the first to bring Listerism to the front in the United States. The vast benefits it conferred were quickly appreciated in branches of our profession other than that of surgery. Closely following the vanguard was midwifery, into which important branch of practice antiseptic surgical principles were soon introduced, for which Henry J. Garrigues deserves special credit.

Notwithstanding its unequivocal results, the progressive tendency of surgery did not permit Listerism to rest upon its achievements. The first forward step naturally was directed toward simplifying its complicated methods. This advance movement was primarily manifested in the decadence of the "spray." The bacteriological investigations, in 1881–1888, of Robert Koch, especially his discovery that the atmo-

spheric microbes are mainly of an innocuous character, led to the conviction that infection was essentially established by contact. The recognition of this fact gave birth to *Asepsis*, as a conscientious method whose advent saved wounds from further contact with toxic substances, such as carbolic acid and mercuric bichloride. Wounds were found to heal without reaction, as the protoplasm in them was no longer impaired by poisons. Skull and abdomen were now opened without thought of danger. In the University Hospital of Munich, asepsis reduced the death-rate in amputations to 2 per cent., while in 1876, the period of early Listerism, the death-rate still was 16.1 per cent. The mortality from ovariotomy has fallen from more than 50 to less than 10 per cent. A similar story might be told as to compound fractures, resections of joints, extirpatio uteri, laparotomies, etc. Amputation of the mammæ, an operation that formerly required from four to six months for perfect recovery, now needed but two weeks. Kocher during early Listerism had nine deaths in 12 resections of the intestines; his later records, covering operations made aseptically, show but two deaths in 13 cases. But it was not surgery alone that was benefited by asepsis: the same strides were made in midwifery, as shown by Von Ramdohr's reports of

400 births, without a single death, at the New York Post-Graduate Lying-in Asylum.

The writer freely confesses that notwithstanding he at first had some doubts regarding the reported results obtained by asepsis in Germany, yet he deemed it expedient to visit, in 1891, among others the clinics of Von Bergmann, Czerny, Schede, and Körte. The results there observed were so striking that he was induced to recross the ocean twice afterward to perfect himself in this inestimable art, a detailed description of which is given in the following pages.

The views and methods described in this volume will undoubtedly change within the next few years, the enormous rush of advancing knowledge relegating to the past for the most part that which to-day is considered incontrovertible. "Tempora mutantur et nos mutamur in illis" will doubtless apply to asepsis no less than it did to antisepsis. However, one thing is sure: the time of "inspiration" is over. The principles upon which aseptic surgery is established are firm, since the theories which have led the technique to its present state of perfection are confirmed by bacteriological tests. This change, however, cannot disturb the glorious foundation laid by Joseph Lister. To Lister we owe the mother, *Antisepsis*, who, though she died in parturition, brought forth her idealization, Asepsis.

SURGICAL ASEPSIS.

I. INFLUENCE OF MICROBES.

Sepsis (σῆψις, putrefaction) is due to the entrance and multiplication of microbes in an organism. *Asepsis* prevents their admission into the human body. To prevent this admission there is requisite a series of procedures, the mastering of which presupposes a perfect knowledge of the characteristics of microbes. Enemies can be combated successfully only when their powers and peculiarities are well known.

The significance of man's most virulent enemies, the very minute organisms called *micro-organisms*, warrants detailed consideration of their powerful and peculiar influence upon the living organism. Generally, four classes of micro-organisms are recognized: (1) The fungi or moulds (Fig. 1); (2) the sprouting or yeast fungi (saccharomycetes, blastomycetes); (3) the fission fungi, bacteria (schizomycetes)—microbes κατ' ἐξοχὴν; and (4) mycetozoa and protozoa.

All dead organic substances in contact with

the atmosphere undergo decomposition, or rather fermentation, leading to putrefaction, which is favored by the combined influences of moisture and warmth. Putrefaction, as proved by Th. Schwann, is produced under the influence of micro-organisms which are everywhere present and everywhere adherent. Their vitality is marvellous. They belong to the lowest class of the vegetable kingdom, and are closely allied to the fungi (Fig. 1). Botanists term them "schizomycetes." These micro-organisms and their derivatives are not only established in any dead organic substratum, but they also, to quote Billroth, under favorable circumstances multiply most rapidly by causing decomposition of the organic substance of their fostering soil, and thereby stir up a series of chemical processes which *finally lead to division of these complicated combinations into simpler ones*. This action of these exciters of decomposition was designated "fermentation." Their effect, unfortunately, is not dependent primarily upon their quantity, which, under favorable circumstances, may be very small, but by constant reproduction they may so rapidly increase as to cause-decomposition until the soil

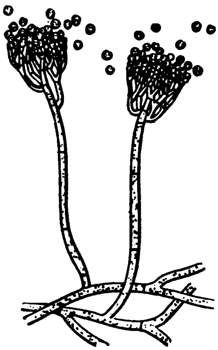


FIG. 1.—Fungi (Penicillium glaucum).

that harbors them becomes exhausted. The rapidity with which microbes multiply is well illustrated by Cohn. He found that a single microbe divides into two within an hour, and subdivides into four at the end of another hour (*Frontispiece*, Fig. 1). Thus the number derived from a single microbe will amount to 16,500,000 in twenty-four hours.

Pasteur classified the microbes under the so-called "organic ferments," to which also belongs the yeast fungus (Fig. 2). To induce fermentation it would suffice that the air, or any solid, or a liquid, containing such microbes, comes in contact with a dead organic substance, the fermentation ceasing only when the microbes have consumed all the material required to keep them alive. But, as will soon be seen, microbes can just as well settle in other than a dead organic substance. The atmosphere has been regarded as an important carrier of these organisms. The microbes, suspended in the air, settle in solid and in liquid bodies, and their vitality is destroyed only by a temperature of 212° F. (100° C.). The conditions of their invasion into the interior of the living organism are furnished by a break in the continuity of the skin or in the mucous membranes; while the

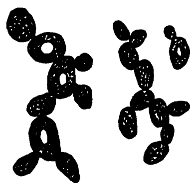


FIG. 2.—Yeast fungi.

conditions for the development and multiplication of the microbe that has invaded or has been brought into the organism prevail wherever there is a favorable soil. Microbes grow best in a temperature varying from 86° to 98° F.

Fully thirty years ago, Pasteur and Billroth recognized the decided influence of micro-organisms upon wounds and inflammatory processes. Lister carried these theoretical investigations into practice. After many erroneous views were corrected, Robert Koch succeeded in isolating certain forms from the enormous quantity of micro-organisms known, and in cultivating them separately on artificial soil. Thus it became possible to study their influence upon living tissues, and to demonstrate their presence therein by characteristic reactions made evident by staining. It was discovered not only that fermentation in dead substances was caused by organic germs, but also that a whole series of pathological processes in the living organism, locally as well as generally, were due to invasion and multiplication of specific microbes. While the ferment germs were formerly regarded as the cause of the peculiar complications in wounds and in inflammatory processes called "accidental wound-diseases," it is now a well-established fact that, besides these germs many varieties of micro-organisms exist which have no connection with

fermentation, but which cause a decided influence upon the living organism.

It has been proved that certain species of microbes cause inflammation, that other species cause suppuration or gangrene, and that the most serious complications in connection with wounds and inflammatory processes—that is, the most frequent and deleterious acute and chronic diseases—are due solely to microbic infection. Microbes, according to the conditions essential to their life, are of two kinds:

(1) *Pathogenous* or *parasitic* microbes, which develop and multiply only within living organisms.

(2) *Saprophytes* or *non-pathogenous* microbes, which depend upon nutriment obtained within dead tissue.

The pathogenous microbes are either (*a*) *facultative* (occasional), depending but *partially* upon nutriment obtained within living organisms, or (*b*) *obligate* (real), which *entirely* depend for their existence upon the soil found within living animal organisms. Only some of the obligate parasites can be cultivated on artificial soil.

The action of these parasites is not the same in all species of animals. One kind of micro-organism may produce intense specific effects in one species of animal, for which it may be pathogenic, while upon another it may

not exert the slightest influence. The so-called "saprophytes" have no influence whatever upon living human tissue, but they may do considerable harm by settling in necrotic tissues and in exudations.

The saprophytes should not be confounded with the pathogenic microbes, which produce specific processes within living tissue. The latter micro-organisms appear in three well-characterized forms—namely: (1) The *micrococcus* (μικρὸς, small; ὁ κόκκος, the kernel) or *coccus*, which presents a spherical form (Fig. 3); (2) the *bacterium* (τὸ βακτήριον, rod)—in the restricted sense of the word—or *bacillus* (a little rod or staff), or staff-shaped micro-organism

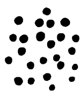


FIG. 3.—Cocci.

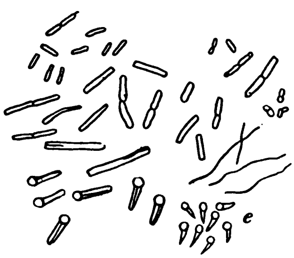


FIG. 4.—Bacilli.

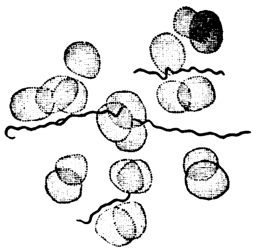


FIG. 5.—Spirillum (relapsing fever).

(Fig. 4); and (3) the *spirillum* (σπεῖρα, a coil), or spiral-shaped micro-organism, which has the appearance of a spirally-twisted thread (vibrio, spirochæte; Fig. 5). These expressions do not indicate

a decided species, but denote only the morphological character of micro-organisms, the different forms of which can be compared best with (1) a billiard-ball, (2) a lead-pencil, and (3) a cork-screw. Their better comprehension demands qualification, such as micrococcus *pyogenes*, bacillus *anthracis*, etc. It is customary now to use the term "bacterium" synonymously with "microbe," and not with "bacillus," which would be the "bacterium *κατ' ἐξοχὴν*."

The cells of the microbes present two essential parts—namely, the nucleus, and the surrounding membrane called the "cell-membrane"—both of them being enclosed in a gelatinous cover. The substance of the nucleus consists of protoplasm, which has the peculiarity that it can be stained by aniline dyes, while the elastic membrane is composed of a substance closely related to cellulose. The membrane is distinguished by its peculiarity of swelling in water.

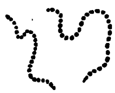


FIG. 6.—Streptococci.

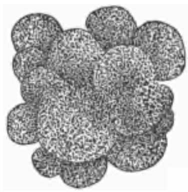


FIG. 7.—Coccoglia.

Cocci and bacilli are either isolated or adherent to each other, or they form chains of from four

to twenty or more rows (streptococcus, streptobacterium, from ὁ στρεπτὸς, the chain; Fig. 6), or they are agglomerated in irregular globular and cylindrical forms by masses of mucus (coccoglia, ἡ γλία or γλοιά, the glue; Fig. 7) excreted by themselves (staphylococcus, ascococcus).

The globular elements differ markedly in size.

FIG. 8.—Flagellate bacilli (typhoid).

They are sometimes as large as a cell-nucleus, or they are equal to the diameter of a globule which can barely be perceived by the strongest magnifying power. They are sometimes movable, sometimes quiescent.

The bacilli are of various lengths. Some are so short that they might be mistaken for cocci; the

longest ones equal 20μ in length. Their thickness is very irregular. Some forms show lively motion in the "migratory stage," induced by their flagella, or thread-like appendages (Fig. 8).

Most species of micro-organisms grow only as cocci, bacilli, or spirilli. Besides these species there are others which vary widely in form during their development. In the quiescent state the organisms either remain isolated or they unite into so-called "colonies" (zoöglœa, *Frontispiece*, Fig. 2) showing peculiarities that are very important in differentiating the species. Multiplication of micro-organisms takes place either by division—that is, one cell splits into two or more similar ones—or by the formation of spores.

As stated before, micro-organisms are found as well in foul or fermenting substances as in the living organism. But they prosper only under the following conditions: 1, they require water in large quantities; 2, they need nitrogenous combinations for their assimilation; 3, they must have a comparatively high temperature (the most favorable temperature being that of the blood). They separate the complicated organic constituents of their fostering soil into a series of much simpler substances, during which process CO_2 is formed and warmth is evolved. This transformation is due to the action of the living protoplasm of the micro-organisms, which

substance probably, like a ferment, is able to segregate a great amount of suitable soil. The products of this change of matter are numerous and are but partially known. They change frequently, according to the form of the microbe and the character of the soil offered. Most frequently hydrosulphuric acid, carbonic acid, carburetted-hydrogen gas, hydrogen, ammonia, water, alcohol, citric acid, aromatics (phenol, tyrosin), and peptones are formed. In addition, many microbes produce ferments; others—and surgically they are the most important—form different substances, known as ptomaïnes (toxines, toxalbumins, cadaver-alkaloids, leucomaïnes), which exercise a virulent influence upon the living organism. These toxic products were detected first in foul liquids and then in decomposing human cadavers. They are bases containing nitrogen; they very much resemble vegetable alkaloids; they are in part products of tissue-metamorphosis in microbes; but it is now known that they are especially produced by microbes within living tissues. Bergmann and Zuelzer obtained virulent extracts from decomposing mixtures, and Brieger and Nencki, who produced a whole series of ptomaïnes, ascertained the combination of their chemical elements. Thus are known some indifferent and some virulent alkaloids which originate in the human cadaver, begin-

ning on the third day after death. Furthermore, it is known that some alkaloids are formed by specific pathogenic microbes. A knowledge of the chemical substances produced by various forms of microbes in their cultures is of the most vital importance, as in most instances local as well as general effects depend upon them. Whenever necrotic tissue or a fluid—for instance, a bloody effusion—is present in a living organism, microbes may develop, while the healthy physiological tissues remain very resistant.

According to Pasteur, microbes should be divided into *aërobic*, those which live best in oxygen, and *anaërobic*, those which not only live without, but generally die in, pure oxygen. Both forms produce decomposition. When an organic fluid is exposed to the free atmosphere, it becomes turbid, because the microbes which fall into it from the air rapidly multiply; *a priori* only the aërobic microbes do so. They quickly consume all the oxygen contained in the liquid, and as soon as they have accomplished this they must die and settle to the bottom of the liquid in the shape of a muddy sediment. Some may continue to live on the surface of the fluid, where they obtain partial nourishment from the atmosphere, and where they form a membrane which gradually thickens and prevents access of oxygen to the liquid and to the organisms held in suspension.

Then the opportunity arises for the anaërobic microbes (*microbes de la putrefaction*, Pasteur) to cause a transformation of the combinations of nitrogen into much more complicated substances. These substances again are so decomposed by the aërobic microbes that they attract oxygen, and while decomposition progresses further the united action of anaërobic and aërobic microbes finally liberates the last products of decomposition—namely, water, carbonic acid, and ammonia.

Some micro-organisms are found in so-called "putrid processes," while others occur in tissues and in fluids which do not show the slightest trace of decomposition—for instance, in abscesses which have not been exposed to the atmosphere at all. Hence it must be assumed that the real decomposing microbes cause only a part of those changes which are ordinarily considered the consequence of infection. As shown before, it is necessary to distinguish between real saprophytes and microbes *κατ' ἐξοχὴν*—that is, between septogenic and pathogenic organisms—although this distinction is only relative. While saprophytes which will settle on wound-surfaces and in cavities, as in the necrotic endometrium of a puerperal uterus or in the intestines, originate ptomaïnes, the absorption of which would be followed by toxic effects upon the living organism,

the pathogenic microbes find the most favorable conditions for their development and multiplication in living tissue—that is, inside of cells, in the blood, in the lymphatics, etc. By thus invading the system they cause a series of disturbances. These pathogenic microbes differ essentially from the decomposing micro-organisms, and are killed by them in dead tissue. Hence decomposition, strange to say, is itself the most effective anti-parasitic agent to overcome the action of such microbes.

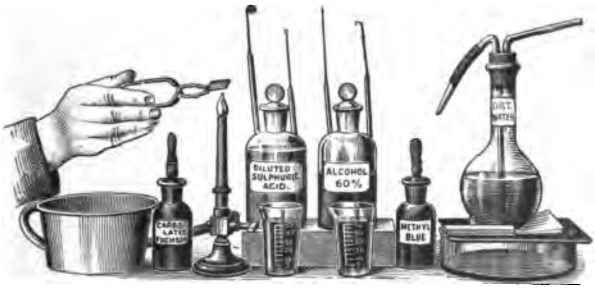


FIG. 9.—Staining the bacillus tuberculosis.

No scientific method of isolating and cultivating a distinct species from a mixture of these different microbes was known until Robert Koch discovered the mode of disseminating a mixture of them over a large surface in order to favor the development of the various species. Then the different forms of vegetation could be recognized with the naked eye as spots or turfs of a peculiar shape, color, growing species, etc. On an

artificially prepared soil, especially on gelatin or on agar, pure cultures can readily be obtained. Some of them are characterized by their capacity to liquefy the gelatin, while others form white dry heaps or white mucilaginous drops, or form colonies of a yellow, green, or red color.

A very important aid in distinguishing these different forms under the microscope is their staining (Fig. 9) with certain coloring matters, especially aniline dyes, and the so-called "Abbé's illumination," a method which allows a distinct

FIG. 10.—Making gelatin cultures.

ocular perception of the stained microbes. Koch's investigations are based upon the necessity of cultivating these species pure; that is, they must be free from all accidental admixtures. In order to obtain this purity in cultivation a small quantity of the substance containing the microbes is implanted upon some suitable liquid soil, meat or agar-agar gelatin, to which peptone is added, being generally preferred (Fig. 10). The soil must

first be freed from all foreign microbes—that is, it must be *sterilized*—and then the cultivation must be conducted in an incubator (Fig. 11). From

FIG. 11.—Incubator.

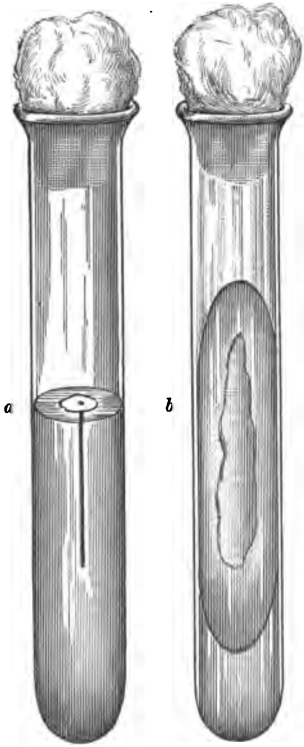


FIG. 12.—Puncture culture (*a*); linear culture (*b*).

the first culture a second, and from the second a third, is made, and so on until a whole series of cultures always produces the same micro-organisms, and no others (Fig. 13); from the last pure

culture a lower animal is then inoculated. If strict precautions are observed, the special microbes *alone* are transferred (Fig. 15). Cultures are made

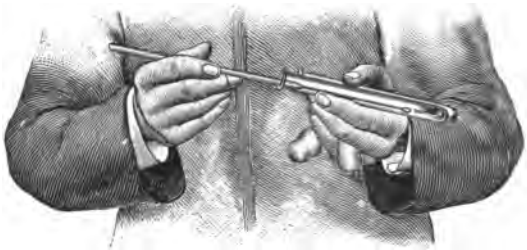


FIG. 13.—Diluting cultures.

either by means of the "hanging drop," that is, by placing a drop of the sterilized nutritive liquid, with the aid of a sterilized platinum wire, upon a

FIG. 14.—Founding plates.

sterilized cover-glass to which a small quantity of the culture is added; or the nutritive gelatin, after being mixed with the cultures and being liquefied in a test-tube, is poured on sterilized

glass plates (Petri's plates; Fig. 14), where the microbes will grow within a day or two.

Of especial importance are the needle-punctures or needle-point cultures (Fig. 12, *a*) and the linear cultures (Fig. 12, *b*). The first are obtained by bringing a platinum wire into contact with a particular colony and then plunging it into gelatin which has been put into a test-tube, the cultures appearing in the area of the puncture obtained by drawing the wire lightly over the surface of the hardened gelatin.

If certain pathological changes make their appearance in the test-animals, these changes must be proven to have been caused entirely by multiplication of the inoculated microbes. Furthermore, the cultivation of one specimen of microbe taken from the inoculated animal must produce the same micro-organism which had been cultivated at first. Only when such experiments are frequently repeated with the same result is it established that the specific micro-organism of a disease is discovered.

It would lead too far to describe the technique of the investigation as well as of the cultivation of these micro-organisms, as it is only possible to become acquainted with these methods by thorough study, without which no surgeon can succeed. As the surgeon of the present day is not justified in performing nephrectomy without

having a thorough knowledge of the pathological changes in the kidneys and of the microscopical examination of the urine, so, if unacquainted with the characteristics of the origin of sepsis, he will have no thorough understanding of the vital importance of aseptic principles.

FIG. 15.—Inoculating a mouse.

The primary influence of a pure culture upon the living tissues is at first mechanical, caused by rapid multiplication and distribution of the colony. This influence depends not only upon the vitality of the culture, but is determined also by the character of the tissue. The secondary influence is due to those peculiar effects caused by the chemical products of the tissue-metamorphosis of the micro-organisms, which show their effects first locally and then generally, by intoxicating the whole system.

These substances, the "toxines," after being absorbed, produce an effect whose intensity depends upon the degree of their reproduction. Microbes are found in all inflammatory processes where suppuration takes place. It is not the presence alone of these so-called "pyogenous microbes" that causes suppuration, but it is also the presence of the chemical substances which are partially evolved in them or which are produced by their soil; therefore the pathological changes differ according to that soil. Thus, large quantities of pyogenous micro-organisms may be absorbed without any harm to the system, if only the accumulation of the products of their tissue-metamorphosis is prevented; while the presence of any quantity of these products in the tissues invariably causes suppuration.

An important factor in suppuration is the property called "chemotaxis," which means the capacity of vegetable as well as of animal cells of being attracted by certain chemical substances. One of these substances is obtained, for instance, by sterilized cultures of the staphylococcus aureus, one of the most frequent pyogenous organisms. Leber called this particular substance "phlogosin." But the same capacity pertains to a series of chemical substances, inorganic as well as organic; as, for instance, mercury, nitrate of silver, turpentine, etc., which, when sterilized—

that is, freed from micro-organisms—produce suppuration; but pus of this kind contains no micro-organisms. The importance of micro-organisms is shown by the fact that by constantly influencing the soil they reproduce pyogenic substances, and that they progressively transport their own independent vegetation from its original focus into the neighboring tissues. Although it has been proved that suppurative inflammation may be

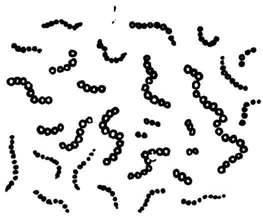


FIG. 16.—Streptococci (Torula).

produced by sterilized substances, the presence of micro-organisms in acute suppurative processes is the rule.

The micro-organisms of most importance from a surgical standpoint are the *pyogenic cocci.* Those which are most frequently found in phlegmonous pus are the staphylococcus pyogenes aureus (*Frontispiece*, Fig. 4), the staphylococcus pyogenes albus, and the streptococcus pyogenes (*Frontispiece*, Fig. 5).

The *staphylococcus pyogenes aureus* (*Frontispiece*, Fig. 4) is found abundantly and nearly

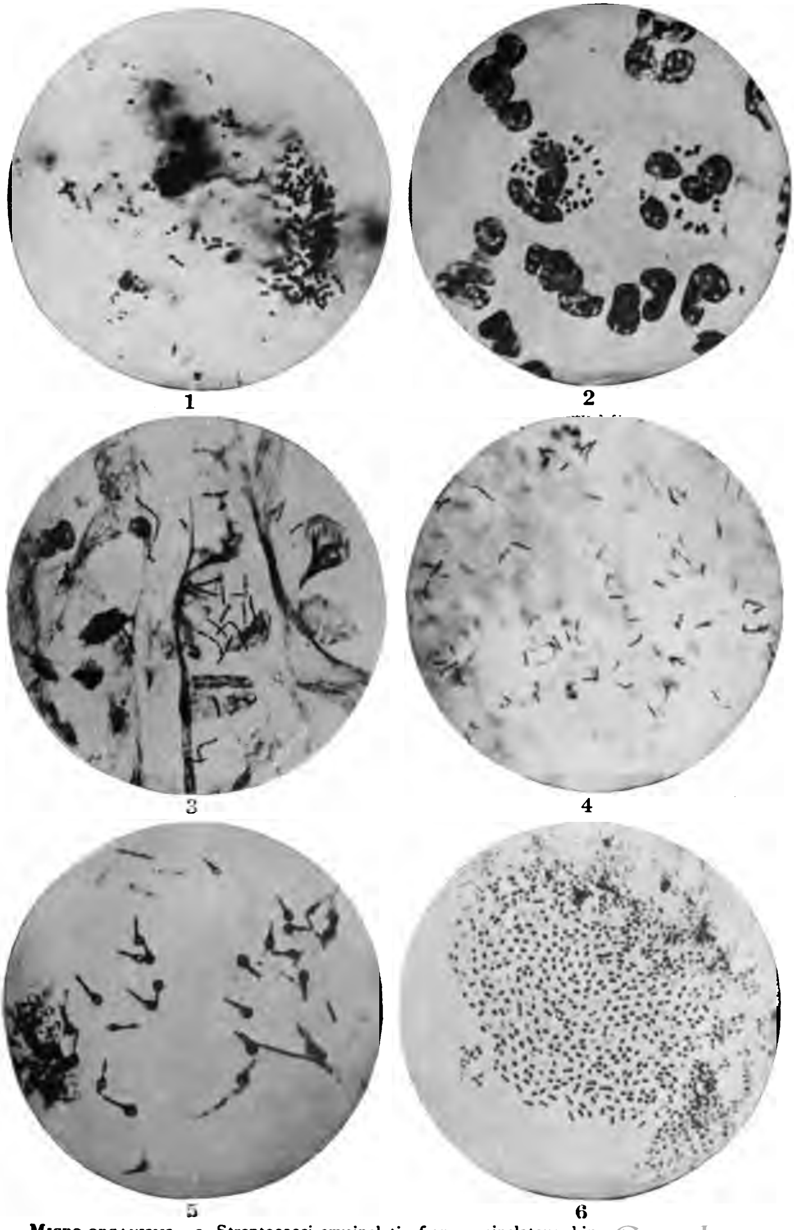
everywhere, its favorite seat being the superficial stratum of the skin, especially of moist parts, as in the axillæ. It is frequently found also under the finger-nails, for which, quite unfortunately from a surgical standpoint, it has a particular predilection. It is found in all kinds of suppurative processes, in carbuncle, acute infectious osteomyelitis, suppurating glands, pyothorax, tonsillar abscesses, lacunar angina, felons, sycosis, impetigo, and suppurative parotitis. Frequently it is found in such processes in company with other pyogenous cocci. The staphylococcus is very resistant to all kinds of chemical disinfection. It stains well in aqueous dyes and by Gram's method. Pure cultures of this highly important microbe were obtained first by Rosenbach. It settles between the tissues in grape-like bunches. It grows on all culture-media of the laboratory, and especially well on potatoes (*Frontispiece*, Fig. 3). On the plates it forms round orange-colored colonies, a characteristic feature of which is that they liquefy gelatin. Numerous experiments proved that staphylococci are the true cause of suppurative inflammation. If they are brought into contact with wounds they produce progressive suppuration. They may even enter through the uninjured skin, probably through the follicles of the sebaceous glands. Garré, by rubbing pure cultures of these cocci into the skin of his arm, produced a carbuncle

in the purulent discharge of which he found staphylococci. Animals can be infected easily by introducing the cultures hypodermatically. These cultures soon form abscesses. If staphylococci are taken up by the circulation, they produce suppurative inflammation of the joints, small abscesses, and metastases in the heart and kidneys.

The *staphylococcus pyogenes citreus* (*Frontispiece*, Fig. 3), first described by Passet, is distinguished from other staphylococci only by the lemon-yellow color of the cultures it produces. It is found only in abscesses.

The *streptococcus pyogenes* (Figs. 6, 16) is one of the most important varieties of the pyogenic cocci. The arrangement of the cocci is in rows or in chains; generally from six to ten rows are attached to one another. Unlike the staphylococci, they grow in small pin-point colonies, and do not liquefy gelatin. Their sites of predilection are in the secretions of the vagina, the urethra, the nose, and in the saliva. The streptococcus pyogenes is the cause of erysipelas, endocarditis ulcerosa, grave polyarthritis, and of spreading inflammatory and metastatic processes (like post-operative peritonitis and puerperal pyæmia, for instance). It can be stained with aqueous aniline dyes and by the method of Gram.

The *streptococcus erysipelatis* (Pl. I., Fig. 1) cannot be distinguished from the preceding coccus,



Micro-organisms.—1. Streptococci erysipelatis, from erysipelatous skin. 2 from gonorrhœal pus. 3. Tubercle bacilli in phthisical sputum. 4. Tubercl lar meningitis. 5. Tetanus bacilli with spores, from agar. 6. Bacillus prodi

and its identity with it is assumed by many investigators. Fehleisen succeeded in cultivating the streptococci found in erysipelas, and reproduced typical erysipelas by inoculating men with the pure cultures. Koch and others, however, long before had demonstrated the presence of microbes in erysipelatous tissue, the margins and lymphatic vessels of which contained them constantly. Lesions of the skin most frequently represent the avenue through which the streptococci enter. The streptococcus is a most virulent microbe and has an immense power of development—a very unfortunate circumstance for a surgeon who takes the risk of going from a case infected by streptococci directly to the operating-room to perform an abdominal section.

The *gonococcus* (Pl. I., Fig. 2), discovered by Neisser, is found in the purulent discharge of urethral and conjunctival gonorrhœa. The gonococci generally can be seen lying within the pus-cells or grouped around the kernels of the cells. Two are usually attached to each other, so that they are recognized as diplococci. Their shape is kidney-like. They can be stained with a simple aqueous-alcoholic solution of methylene blue, which stains the cocci a dark blue color, while the kernels of the pus-cells appear light blue. By Gram's method they can be decolorized. Another valuable method of staining is that of

treating preparations with a concentrated solution of eosin. Cultivation of this important microbe outside the human body is difficult, and is only successful on blood-serum, which can be obtained from a placenta. The gonococcus forms a nearly colorless coating of small extent. Cultures die after three days. Bumm, by transferring cultures into the urethra of men, produced typical gonorrhœa. Animals are immune against this coccus, therefore it must be assumed that it is a real human parasite which does not find a soil in other organisms. The typical shape and the situation within the pus-cells are valuable characteristics of the gonococci, and make their recognition comparatively easy.

The *diplococcus pneumoniæ*, discovered by Fraenkel in the rusty sputa of patients affected with pneumonia, is supposed to be the cause of pneumonia. It is an encapsulated, lancet-shaped microbe. Besides its favorite seat in the lungs, it is found in meningitis cerebro-spinalis epidemica (Foà and Bordoni), in suppurative otitis media (Weichselbaum), in primary nephritis, in endocarditis ulcerosa, in pleuritis, pyothorax, and pericarditis, and also in the sputa of healthy individuals. Animals inoculated with small quantities of human sputum die from the so-called "sputum-septicæmia." The diplococcus can be stained with diluted alcoholic dyes, and also by Gram's method.

The *pneumococcus Friedländer*, which ought to be called a bacillus, as it is of an oblong shape, has also been cultivated by Friedländer from the sputa of patients suffering from pneumonia. It can easily be distinguished from the former coccus, as it does not stain by Gram's method.

Among the bacilli, the following are of surgical interest:

The *bacillus coli communis* (bacterium coli commune) has been found by Escherich constantly in the intestines of nursing children; this bacillus was also found in places where typhus fever was endemic. The bacillus is thin and from 0.3–0.4 micromillimetres in length. It possesses little power of motion. It can be stained with the ordinary dyes, and may be decolorized by the method of Gram. On gelatin the colonies form a thin superficial coating of a white color and with an irregular margin. They do not liquefy gelatin, nor do they form spores. Rabbits inoculated with this bacillus die one, two, or three days after hypodermatic injections of the cultures.

This bacillus is an essential factor in suppurative peritonitis; it does not, however, appear to be the only cause of this condition. The streptococcus is frequently found in company with it, and Welch's observation, that the colonies of the bacillus coli communis grow so rapidly and extensively that the smaller ones of the streptococci are

so overshadowed that they are overlooked, would point to an accompanying excitation of inflammation by the two microbes.

The *bacillus pyocyaneus* is the cause of the green or blue color of dressings saturated with pus. This bacillus, a small slim rod, possesses considerable motile power. Gessard isolated it first, and Löffler made the observation that one thread is always attached to it. It does not contain spores. Gelatin, on being liquefied through its colonies, assumes a green fluorescent color. On potatoes a yellow-green coating can be cultivated, which can be stained red by acids, while ammonia stains it green-blue, the coloring matter thereby obtained being called "pyocyanin." This bacillus, which can be stained with the ordinary dyes, is widely distributed. In hospitals true epidemics of blue pus have often been observed. It is highly infectious for rabbits, and sometimes also for men. There is no doubt that it is pyogenic as well as chromogenic.

The *bacillus tuberculosis* (Pl. I., Figs. 3, 4) was discovered by Robert Koch, who produced tuberculosis artificially by inoculating animals with pure cultures. The microscopical test disclosed its presence in all tubercular tissue and in the sputa of tuberculous patients. More than a hundred years ago, however, tuberculosis was supposed to be an infectious disease, and in 1865 Villemin

succeeded in transferring tubercular substances to rabbits and produced tuberculosis in them. A few years later, Cohnheim obtained the same results by inoculating the corneæ of rabbits, thereby proving tuberculosis to be a true infectious disease.

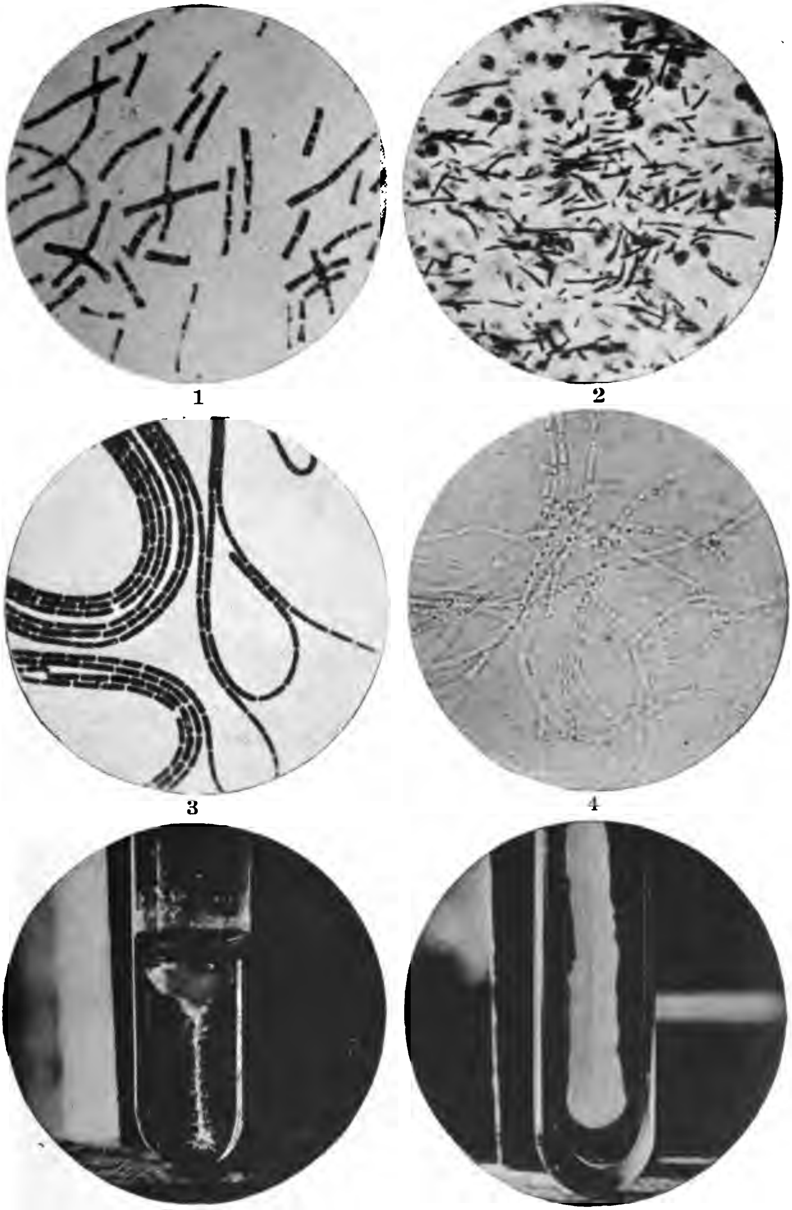
The tubercle bacillus is a small slim rod which possesses no power of motion. It is easily stained by the methods of Koch and Ehrlich, and by the methods of Friedländer, Günther, and Biedert. Characteristics of the bacilli are their power of resistance, their taking up of dyes, and the difficulty of decolorizing the cells. It is the cause of tuberculosis of the lungs and of lupus. There is hardly a tissue in the body that may not become the primary seat of tuberculosis. (This primary seat is often overlooked after the tubercular process has spread.) If it is borne in mind that at least one-seventh of mankind succumb to some kind of tuberculosis, a slight idea may be gained of the importance of this bacillus, the detailed properties of which cannot be elucidated in the limited space of this book.

The *bacillus tetani* (Pl. I., Fig. 5) was discovered by Nicolaier in garden soil and in the feces of herbivorous animals, as well as in the pus of individuals who had succumbed to tetanus. Kitasato was the first who isolated the bacillus in pure cultures. Carle and Rattone, however,

previously discovered that tetanus was an infectious disease. The bacillus stains with cold aqueous dyes and by the method of Gram. It is a small rod, possesses little power of motion, and forms spores of a circular shape. It is an obligate anaërobe, and it is one of the most deleterious bacilli. Before the rules of antisepsis or asepsis were known and during the period when they were poorly observed endemics of tetanus were repeatedly experienced. If the tetanus bacillus is implanted into the spine or the sciatic nerve of a rabbit, the symptoms of tetanus will be observed within twenty-four hours, and the animal will die in from two to four days.

The *bacillus anthracis* (Pl. II., Figs. 1–5), discovered by Pollender, was first isolated by Koch. It is an immovable rod to which spores, as a rule, are attached (Fig. 17). On gelatin it forms small, white, pin-point colonies which liquefy their soil slowly. It stains well with the ordinary dyes and by the method of Gram. In cows and horses infection takes place from injections, while in men the bacillus enters small wounds of the skin, thereby causing the so-called "pustula maligna." Rag-pickers are apt to acquire anthrax pulmonum by inhaling anthrax spores.

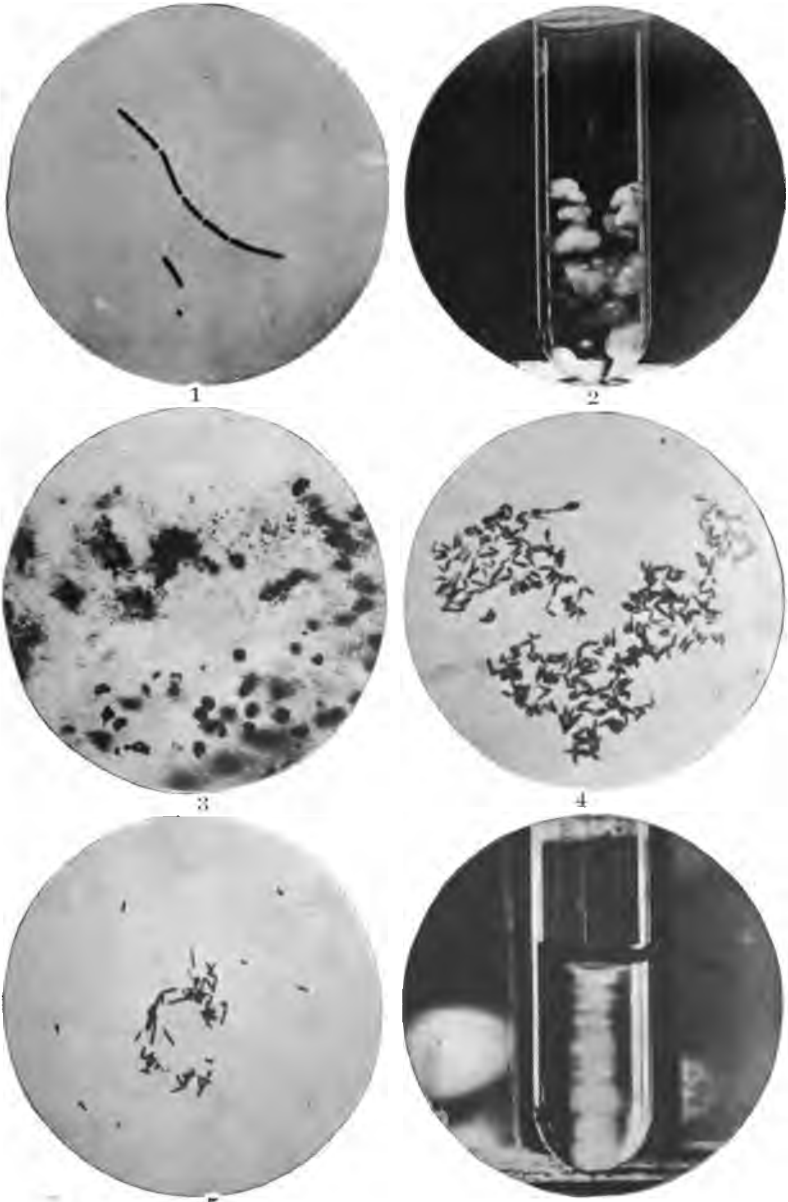
The *bacillus of malignant œdema* (Pl. III., Figs. 1, 2), described by Pasteur as "vibrion septique," was discovered by Koch. It finds a nidus in the



MICRO-ORGANISMS.—1–3. Anthrax bacilli: 1, cover-glass preparation: 2, from the spleen of a mouse; 3, from cultures on a Petri plate. 4. Anthrax bacilli with spores, from a gelatin culture. 5. Anthrax cultures. 6. Cultures of typhus bacilli.





MICRO-ORGANISMS.—1. Bacillus of malignant œdema, from œdematous serum. 2. Cultures of the bacillus of malignant œdema. 3. Diphtheria bacilli, from a diphtheritic membrane. 4. Diphtheria bacilli, from an agar culture. 5. Bacillus of mouse-septicæmia, taken from blood. 6. Cultures of mouse-septicæmia.

superficial layers of ordinary garden soil and in the dirt and dust of carpeted floors. It has the length of the anthrax bacillus, and possesses considerable power of motion, which is produced by its flagella. Colonies liquefy gelatin. As it is an obligate anaërobe, it can be cultivated only when the atmosphere is excluded. Men as well as animals are susceptible to this bacillus, which

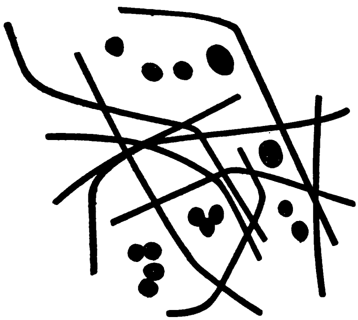


FIG. 17.—Strings of anthrax bacilli.

can be stained with cold aqueous dyes. It can be decolorized by the method of Gram.

The *bacillus diphtheriæ* (Pl. III., Figs. 3, 4) was discovered by Löffler. Roux, Escherich, Brieger, and Fraenkel produced true diphtheria by transferring cultures upon the opened trachea of rabbits and guinea-pigs. The bacillus diphtheriæ is a straight or slightly bent rod of the size of the tubercle bacillus. It is not movable, does not contain spores, and does not liquefy gelatin. It

can be stained with alcoholic aqueous dyes and by Gram's method.

Other microbes, like the bacterium lactis aërogenes, the bacillus lepræ, of rhinoscleroma, of malleus, and of typhus, the vibrio choleræ Asiaticæ, and the spirillum of recurrent fever and of malaria, are of comparatively little importance so far as concerns their direct interference with wounds.

One of the most interesting non-pathogenic bacilli is the *bacillus prodigiosus* (Pl. I., Fig. 6), which is found sometimes on moist bread, potatoes, or in milk. Its cultures produce a red color, which has been the foundation for the legends of the bleeding bread, the bleeding holy wafers, etc.

A peculiar *fungus* is the actinomyces (ray fungus, actinomyces bovis s. hominis; Figs. 18, 19), discovered as early as 1845 by B. von Langenbeck in a vertebral abscess of a man. It used to be classed among the hyphomycetes (mould fungi), but is now regarded simply as a variety of schizomycetes. Its favorite domicile is the maxillæ of cattle, where it causes indurated tumor-like masses which undergo softening and suppuration. In man the lower jaw (Fig. 19) also is most frequently the primary focus of this malignant disease, which extends continuously into the adjacent tissue and to internal organs, as the lungs, the pleuræ, the heart, the liver, the

kidneys, the intestines, and the brain. The actinomyces can be cultivated on agar by cutting off oxygen, in which event yellowish-white colonies are formed; but if the air has free access an ochre-colored appearance is obtained. Pure cultures injected into the cavum peritonei of rabbits

FIG. 18.—Actinomyces.

FIG. 19.—Actinomycosis.

produce typical actinomycosis. The fungus stains well with the ordinary aniline dyes and by the method of Gram.

The human body may be invaded by these micro-organisms through solutions of continuity either of the skin or of the mucous membranes where the microbes fall directly upon them. As a rule, however, they are transferred or are inoculated by other substances to which they adhere—

that is, by the wounding instrument, by the fingers, by clothing, or by unclean wound-dressings. The hair-follicles and the sebaceous follicles may also be factors in this process.

In view of recent investigations, it seems more and more positive that the air has no bearing upon infection, but that contact is all-important. In other words, the millions of micro-organisms suspended in the air and which may invade a wound are usually innocent and of an indifferent character. Were this otherwise, it would be impossible to perform laparotomies and similar serious operations in large surgical amphitheatres (where several hundred students are present) with the same success as is done in operating-rooms, where the walls, floors, and ceilings are constructed of marble, and where, besides the patient, none but the operator and his assistants are present.

Lister originally thought that the atmospheric micro-organisms causing decomposition in organic substances are identical with those that infect wounds; therefore he regarded the *air* as the most important enemy to be combated. For this purpose he very naturally advised his spray.

Nowadays diametrically opposite views are held; that is, the air is deemed the most unfavorable place for these micro-organisms, it having been proved that most infecting microbes of

Microscope with Abbé's apparatus.

wounds are destroyed shortly after they reach the atmosphere. When no solution of continuity of the tissue is present, it has been supposed that probably the pyogenic cocci enter through the mucous membranes of the respiratory or the digestive tract, and that migratory cells containing microbes invade the lymph- and blood-circulation by migrating through the mucous membrane. It was further assumed that they might then establish themselves at any point in the system, and there develop and multiply.

At the German Poliklinik the writer observed a typical cause of swollen and suppurating glands, which condition he generally designated as "dirt inflammation." Some classes of immigrants, coming from semi-barbarous districts, regard even an annual bath as an extravagant and foolish luxury, and carry all imaginable varieties of mother earth, especially on those surfaces of the body not covered by clothing. When they scratch themselves —for obvious reasons—they become self-inoculated with the microbes harbored in their well-cultivated filth.[1] As bacteriological investigations proved, in most of these cases the staphylococcus pyogenes aureus, sometimes the staphylococcus (epidermidis) albus, was found.

Locally the microbes rapidly multiply and find

[1] "Surgical Diseases of the Neck," *New York Med. Journal*, April 29, 1893.

their way into the connective-tissue cells and the walls of the blood-vessels. Within twenty-four hours exudation and emigration start as direct consequences of the so-called "phlogosin" (Leber) caused by the microbes.

The white blood-corpuscles are attracted by the microbes and take them up into their protoplasm precisely as they might take up pigment, transporting them into the tissues by their active locomotion. The leucocytes and microbes accumulate more and more, while cellular infiltration and germ-formation progress toward the periphery. Within two or three days softening and breaking up of the tissues take place in the centre of the focus of the inflammation; in brief, an abscess forms.

There are still some weak points in the above explanation of the origin of pus-accumulation, as, besides those described above, there are present other micro-organisms which may be of some importance in this connection. Buchner, for instance, in examining seventeen forms of bacteria, found a substance that he called "bacterio-proteine," which he deemed the real cause of suppuration. This substance, he claims, is set free only when the bacteria are dead.

The question then arises: Are the bacteria in an abscess alive or dead? In other words, is suppuration caused by the vital manifestations of

bacteria, or by such substances as form only after their death? Every abscess contains numerous staphylococci or streptococci, either alive or dead. But, besides these organisms, there may be present other forms of micro-organisms, which perhaps remain unrecognized because of the present defective means of cultivating them.

At any rate, it can hardly be conceived how staphylococci or streptococci *alone* can cause a series of very different diseases; how streptococci of endocarditis, for instance, should be the origin of rheumatism, of tonsillitis, of osteomyelitis, of cerebro-spinal meningitis, of cryptogenetic pyæmia, of septicæmia, of carbuncle, etc. Can it, then, really be true that an innocent tonsillitis has the same origin as cerebro-spinal meningitis, and that only the difference of the microbes' scenes of action furnishes the variation in their significance?

Reger [1] advances the theory that most infectious diseases, especially the so-called "pus-diseases," are nothing but the local expression of general infection caused by a great number of different micro-organisms. Similar views are expressed by Heim.[2] The course which infectious processes take is supposed to be influenced by the disposition of the patient, by the oppor-

[1] *Verhandlungen der deutschen Gesellschaft für Chirurgie*, XXIII. Congress, 1894.

[2] *Lehrbuch der bakteriologischen Untersuchung und Diagnostik*, Stuttgart, 1894.

tunity offered by his *locus minoris resistentiæ*, and by the predilection of the different micro-organisms for one place or another. Reger distinguished two different typical groups of infectious diseases: (*a*) Specific contagious diseases: measles, rubeola, parotitis, varicellæ, diphtheria, scarlet fever, influenza, pneumonia, erysipelas, and conjunctivitis; (*b*) Pus-diseases: catarrhs and inflammations of the mucous membranes of the respiratory and digestive tracts, the anginæ, the inflammatory organic diseases, rheumatism, inflammatory processes of the skin-surface, and diseases which are accompanied by suppuration or by the formation of serum, fibrin, or muco-pus, and which are dependent upon direct contact with pus or dirt, upon the influence of an external climatic noxiousness, or upon a certain diathesis. In the progress of these pus-diseases Reger found exactly the same regular course as in the other group of infectious diseases. He therefore concludes that the usual classification of all diseases has up to the present been wrong, and that these diseases were all named either after their most predominant symptom or after the organ which is most involved, instead of being named after their true originators, the microbes. The whole classification customary through centuries could be due only to our ignorance of etiology.

It is thus seen that there are still many important questions awaiting elucidation, which can first and foremost be given by bacteriological experiments. Surgery especially has made such wonderful advances within the past twenty-five years as to justify great enthusiasm for the results of the science in the near future. The main requisite for its further development will be the creation of surgico-bacteriological laboratories. The experience gained by abundant surgical material will then go hand in hand with all the advances of modern chemistry and bacteriology, forming a new and extremely useful combination.

II. THE IMPORTANCE OF ASEPSIS.

Asepsis is the offspring of antisepsis. Both methods tend to the same end. At the present time it is very difficult to draw a line of demarcation between them, much more so as treatment cannot strictly be *aseptic* without employing means of disinfection—that is, following *antiseptic* principles to a certain extent.

Antisepsis, in the original acceptation of the word, was supposed to mean a method of preventing fermentation or putrefaction. The result obtained by observing its rules would be asepsis. An aseptic wound was originally deemed one which was so well disinfected by antiseptics that

no putrefaction could take place in it; but at present the word asepsis is generally employed in contradistinction to antisepsis. Instead of striving to kill microbes brought into contact with a wound by the use of more or less poisonous chemical procedures, the endeavor is now to keep the wound free from microbes without employing so-called "germicidal" chemical agents. Whenever chemical substances can be avoided during an operation, physical methods of disinfection are substituted. Thus the aseptic method is by its nature more of a prophylactic, as well as more of a non-poisonous, character than originally was the antiseptic.

An aseptic wound is supposed, on the one hand, to be a wound which has not first been infected and then freed from micro-organisms by disinfection; on the other hand, it is impossible to conceive among aseptic paraphernalia articles that have never been brought into contact with micro-organisms, such as instruments, operating-tables, operating-rooms, etc. Here the aseptic designation signifies only that the articles employed *can easily be rendered aseptic.* For instance, an instrument having a metal handle can more readily be made aseptic than one whose handle consists of wood or of hard rubber.

Recent investigations by Robert Koch, E. von Bergmann, Schimmelbusch, Schlange, Riedel,

Neuber, Tait, Koeberlé, Geppert, Miguel, Redard, Fraenkel, Nissen, Schaeffer, Behring, Gerloczy, New, Laplace, and others clearly show that the so-called "germicidal" chemical substances do not possess the disinfecting power that was long attributed to them. This over-estimation is due to the former mistake of transferring small quantities of the antiseptic fluid to the culture soil at one time. A piece of gauze, tested as to its sterility, will serve as an illustration. If the gauze is put on suitable soil and a small quantity of an antiseptic fluid is transferred with it, the soil becomes impaired and the microbes naturally fail to multiply.

Koch divided the object to be disinfected—for instance, infected silk thread—into minute portions, while the soil represented a considerable area, with a view to great dilution during culture. This experiment was followed by surprising results. The bacillus of anthrax retained all its vitality even after being exposed for two weeks to the influence of a 5 per cent. solution of carbolic acid. Similar results were obtained with strong bichloride solutions. Even the most liberal irrigation with bichloride of mercury did not necessarily prevent sepsis. This drug, which was supposed to be the strongest antiseptic, does not destroy bacteria with certainty. Moreover, as all antiseptics more or less impair the

tissues of wound-surfaces, their resistance to the microbes is weakened.

But, despite all these disadvantages, it would have been unjustifiable to dispense with antiseptic solutions so long as they were credited with positive and rapid germicidal power. Thanks to very careful application of such solutions in the hands of great masters, these disadvantages have been counterbalanced by their advantages. That Lister himself appreciated these disadvantages is manifested by the fact that even at the time of his first publications he advised a series of precautions regarding the use of carbolic acid, which he characterized as a disagreeable necessity, especially because of its irritating action on the tissues.

United aseptic wounds heal much more quickly than wounds washed with antiseptic solutions. In the former, suppuration and other disturbances are observed only exceptionally; secretion is also much more scanty, thus rendering drainage unnecessary. Poisoning with such drugs as carbolic acid, bichloride of mercury, iodoform, etc. need not be feared, as they are not required in united wounds. Dressings do not require such frequent changes as formerly, and asepsis is far more economical than antisepsis.

The advantages of asepsis are manifest especially in operations on the peritoneum, which

seems to react more readily to the application of antiseptic solutions than any other organ. Therefore these strong and most desirable drugs cannot be employed within the abdominal cavity, as the great tendency toward absorption, which is another characteristic mark of the peritoneal membrane, would favor general poisoning. If infection by contact has been prevented beforehand—that is, if all objects which touch the peritoneum during an operation are freed from micro-organisms—the abdominal cavity may safely be closed. No septic agent will remain in the cavum peritonei, and all microbes that may have fallen into the cavity from the air are innocent (compare the experiments of Petri and Cleves-Symmer, p. 147), and will be kept in check by the living tissue itself.

No reaction, as a rule, follows laparotomies performed aseptically, and even inflammatory processes, which are frequently observed after the use of antiseptic solutions, appear only under the most exceptional circumstances. The same conditions, especially absence of reaction, are verified in carrying aseptic principles over to other healthy (non-infected) tissues.

Asepsis proves to be so far superior to antisepsis that the method to be carried out has ceased to be a matter of choice. *It is simply the duty of every surgeon to substitute asepsis for anti-*

sepsis, and to utilize the latter only as a part of the aseptic method.

Aseptic maxims were more or less conscientiously advanced by Czerny, Neuber, Tait, and others. Czerny as early as 1877 boiled his silk ligatures. The splendid results obtained by Neuber, Tait, and others by the observation of the ordinary principles of cleanliness are universally known. But evidently ideas on the subject of asepsis had occurred long before; they apparently date back to before the Christian era, when some of the principles of asepsis were more or less consciously carried out. Much of the admirable knowledge of the great Hippocratic era was lost during twenty-three centuries. Is it not astonishing that Hippocrates laid great stress upon frequently washing the patient with warm water before performing an operation? Does not this extraordinary cleanliness appear like the dawn of aseptic principles? Is it not an explanation of the success of operations so signally performed at that period that some are inclined to doubt the authenticity of the records? It would suit the spirit of our sterilizing age to be reminded of the frequent washings by the Jews—a religious rite ordained by Moses, who doubtless was one of the greatest judges of human requirements.

A slight indication of what must have been lost of the immense knowledge of the school of

Kos, and of how advanced Roman surgery must have been, may be gained by visiting "the house of the surgeon" at Pompeii. The streams of water constantly flowing through the streets of Roman cities were certainly apt to remove microbes. Furthermore—and the writer is not aware that it has ever been mentioned from this point of view—the large number of small wells in the "house of the surgeon" suggests at least some vague knowledge of the principles of asepsis.

At a recent visit to this most interesting place the writer instinctively felt more than ever before how little advanced in many respects is the present age when compared with the medical civilization of many centuries ago. Why should not the ancient surgeon, with his fine art of diagnosis and with his powerful weapon "cleanliness," have obtained better results than the surgeon of not many years ago, who went directly from the autopsy-room, after having washed his hands superficially with soap and water, to the operating-room, repeating his anatomical masterpiece on the living subject, which was thus frequently made a specimen for the autopsy-room?

The instruments excavated at Herculaneum and at Pompeii, and now exhibited in the Vatican at Rome and in the Museo Borbonico at Naples, are all of the most admirable perfection; being made of steel or of bronze, they are aseptic.

Clear and conscientious aseptic principles, however, date only from the time Robert Koch's genius created their scientific base by testing the value of our disinfecting means by bacteriological investigations. On this bacteriological foundation Kuemmell, Fuerbringer, Von Bergmann, Schimmelbusch, Braatz, Saenger, Tripier, Kelly, and others were able to elaborate the principles of their standard methods.

III. MEANS OF DISINFECTION.

It is undeniable that microbes have been found in wounds that have healed without the slightest reaction. Hence it must be assumed that infection does not necessarily depend upon the invasion of a single microbe, but that it depends upon the quality or the quantity of microbes present.

Killing microbes is certainly the safest manner of preventing their deleterious influence upon wounds. Various ways of accomplishing this extermination are known: some methods are to destroy the microbes directly, to prevent their development and multiplication, or to remove them mechanically. Nothing definite can yet be said as to the value of other methods, such as the employment of so-called "anti-toxic" substances, or of such medicaments as, it is alleged,

deprive the micro-organisms of their virulence, or of procedures directed to rendering the system immune against the invasion of microbes.

Sunlight also possesses disinfecting power. Arloing found that anthrax spores cultivated in bouillon died in a few hours on being exposed to direct sunlight. Koch saw cultures of tubercle bacilli die out in from five to seven days by simply placing them at a window. This would explain why simple laparotomy is apt to cure peritoneal tuberculosis. Spilken, Gottstein, and Krueger found that *electricity* is able also to destroy microbes.

The most effective, and therefore the most important, means of disinfection is the *mechanical method*, which may safely be said to be at least three-fourths asepsis. It is accomplished by removing all dust and dirt by the use of brushes, a nail-cleaner, etc. Manifestly, if the micro-organisms are thus brushed off, they do not require any more disinfection; *vice versâ*, dirt under the finger-nails, no matter how long kept in a strong antiseptic solution, contains sufficient micro-organisms of ample vitality to produce infection if the mechanical cleansing process is not thoroughly carried out. Therefore any question as to the greater and lesser virulence of such micro-organisms as can mechanically be removed is entirely irrelevant. The value of the so-called

"bactericidal" methods of disinfection depends upon the proofs furnished by culture-tests as made by Koch.

In addition to the points alluded to in Section I., on the "Influence of Microbes," one further factor demands consideration—namely, the presence of *spores*, whose vitality differs materially from that of other organisms. Organisms containing spores, such as the anthrax bacilli, are more difficult to destroy than are those organisms which do not contain spores. While a 2 per cent. solution of carbolic acid is apt to kill the bacillus of anthrax in one minute, the spores of the same bacillus are not influenced by a 5 per cent. solution of carbolic acid, even if they are kept in it for weeks; therefore the bacilli must necessarily be well distinguished from the spores.

The following microbes contain no spores: the streptococcus pyogenes, the streptococcus erysipelatis, the staphylococcus pyogenes aureus, albus, and citreus, and the bacilli of diphtheria and of malleus. The following bacilli contain spores: the bacillus tuberculosis, anthracis, and tetani. Tetanus spores are more easily destroyed than are those of anthrax or of tuberculosis. In practice they may ordinarily be left out of consideration as regards wound-disinfection. What is needed, as a rule, is to prevent the contact especially of such cocci as the staphylococcus pyo-

genes and the streptococcus pyogenes or erysipelatis with wounds, instruments, dressings, etc.

As the development and multiplication of micro-organisms is predicated upon a favorable soil with a certain temperature and quantity of moisture, their vitality very naturally can be destroyed by depriving them of these essentials. This deprivation can be effected by *chemical substances* as well as by *heat*, which may be utilized as steam, as hot air, and as boiling water. The last mentioned is the most powerful germicidal agent of all. Heat, by the way, was employed by Hippocrates and Oribasius, who recommended using the hot iron and boiling oil upon wounds, not only to arrest hemorrhage, but, as is maintained, also to cleanse.

The picture showing Ambroise Paré in the act of cauterizing with a hot iron the amputation-wound of a soldier's leg is well known. Recently, M. G. Phocas of Lille, Felizet,[1] Dreesnau,[2] and M. Feannel[3] recommended the flame of a gas-jet for sterilizing wounds, or the pouring of oil into the cavities and bringing it to the boiling-point by a hot iron, or simply the touching of the wound-surface with boiling water. The latter procedure appears to be the most rational among those

[1] *Bulletin de la Chirurgie*, 1892.
[2] *Centralblatt für Chirurgie*, 1893, No. 3.
[3] *Gazette des Hôpitaux*, Nos. 59 and 62.

named, as certainly it is the least injurious to the tissues. Boiling water destroys all forms of cocci in from one to five seconds, and the spores of the bacillus anthracis in two minutes. Steam destroys the spores in fifteen minutes, while tubercle bacilli require twenty minutes. A 0.1 per cent. solution of bichloride of mercury fails to destroy the spores of the bacillus anthracis in twenty-four hours; chlorine, iodine, and the cresols are equally powerless. A 5 per cent. solution of carbolic acid, as also the coal-tar derivatives, requires much longer; even chloride of calcium destroys the spores of the anthrax bacillus only after five days', and ether after thirty days', immersion.

In view of these statements, the exactness of which can no longer be doubted, it is surprising that with 2 per cent. solutions of carbolic acid comparatively good results were, and are still, obtained, and that many surgeons continue to express their great satisfaction with, and their abiding faith in, this drug, and therefore seek no change. Yet it is beyond cavil that these so-called "satisfactory" results are due, not to the influence of a weak solution of carbolic acid poured upon the instruments a few minutes before operation, but to conscientiously following *aseptic principles*, the fundamental one of which is the thorough mechanical cleansing of instruments, the surgeon's hands, and the field of operation.

If an abscess has been incised, it cannot be expected that the knife, after having remained in a solution of carbolic acid for a few minutes, or even for an hour or more, becomes so well disinfected that it may safely be used for a subsequent plastic operation or for opening a similar abscess. Even if the knife was cleansed mechanically before being immersed in the solution, it would perhaps require many hours to render it aseptic. Manifestly, no surgeon can wait so long. But if he simply dips the knife into boiling water for two minutes, he is absolutely sure of its being perfectly aseptic. *If, then, boiling water is so superior to all chemical substances, so far as concerns the certain as well as the quick destruction of microbes, it should be substituted for these substances whenever possible.* The addition of soda (1 : 100) prevents the rusting of the instruments and increases the disinfecting power of boiling water. A further great advantage of this method of disinfection is its simplicity and small expense.

As shown in Sections VIII. and XVI., boiling water in an ordinary kitchen pot, and the addition of a tablespoonful of soda, which may be found in the poorest tenement-house, are all that are required for thorough disinfection. In a similar way the dressings may be rendered aseptic. The difficulty of impregnating gauze, cotton, or other

dressing material with chemical substances, if glycerin or fatty or resinous ingredients are not added, is well known. All these constituents necessarily diminish the absorbent power of the dressing.

It has always been the general aim to add so-called "antiseptic" substances to the gauze, to prevent decomposition of the discharges from wounds into the gauze. No chemical substance has been found that acts so powerfully in this direction as *dryness*. Dryness is one of the three important enemies of bacteria, as above stated. Exposing bacteria to dryness deprives them of moisture, one of the conditions necessary for their life.

Only in cases of very severe infection, where thick and putrid secretion (ichor) is present, can the principle of drying not be carried out; in which cases the surgeon may rely upon another enemy of bacteria—anaërobiosis (see p. 27). Anaërobic microbes, as a rule, die in pure oxygen, while aërobic microbes multiply in oxygen, but die when deprived of it.

In wound-cavities oxygen is absent; therefore in such a cavity anaërobic microbes find favorable conditions, while if the cavity be exposed by large incision, thus freely admitting oxygen, anaërobic microbes will necessarily be destroyed. These well-proved facts form the bacteriological

basis of the *open-wound treatment*, to which the surgeon must resort in cases of infection (p. 176), and which will be discussed in Section XI.

If gauze be exposed to a jet of steam for twenty minutes, all microbes are destroyed. Ordinarily, such gauze is superior to impregnated gauze, on account of its much greater absorbent power. Furthermore, it is very questionable if all the dressings containing bichloride of mercury, carbolic, salicylic, or boric acids, iodoform, or ether are perfectly aseptic, as they are made in factories where they must be handled by many individuals. It can scarcely be expected that these working-people have full knowledge of their great responsibility.

The germicidal power of chemical substances will often be impaired if they form combinations with the substances they encounter, which combinations may sometimes account for the untoward results of disinfection. For instance, neither fæces nor sputa can be disinfected with bichloride or other antiseptic solutions. The disinfecting power of corrosive sublimate upon pus and blood is very small, and when used upon such albuminoids it can be intensified only if tartaric acid be added. An antiseptic agent which may be powerful in a watery fluid containing spores of the bacillus anthracis may be useless in alkaline and acid fluids or in albuminous mixtures. Another great

difficulty in disinfection lies in the fact that the disinfectant may not directly reach the seat of the microbes.

There is a great difference between disinfecting an instrument contaminated by infectious material and disinfecting a nest of bacteria imbedded in filth and similar substances or in necrotic tissue. Eight years ago, the writer[1] emphasized the fact that the bacilli of diphtheria cannot be destroyed as long as they multiply beneath the membrane, from which all antiseptic substances rebound. A local rational treatment can be carried out only if the antiseptic substances penetrate the necrotic tissue—that is, if the membrane is removed first, so that the microbes that have settled in the sub-membranous tissue can directly be attacked.

The writer has several times, and with apparent success, tried to remove the diphtheritic membranes with the sharp curette, afterward applying a bichloride spray (1 : 1000) every fifteen minutes during the first twenty-four hours. In performing tracheotomy in a family where four children suffered from diphtheria at the same time, the writer happened to notice an extensive diphtheritic membrane on the labia majora of the baby. After having curetted the membranes and dressed the affected surface, the temperature in

[1] *New Yorker medicinische Presse.*

seven hours fell from 104° to 99°. The swelling of the neighboring glands also subsided promptly. The effect was so obvious that the same procedure was tried on the tonsils. The apparent cruelty of this treatment, the irritation of the healthy mucous membrane, and the difficulty of employing the treatment as soon as the naso-pharyngeal vault has been reached by the diphtheritic process, naturally prevented its adoption in its present shape by the profession. The use of the galvano-cautery, which was advised later on, experienced the same fate.

A. Seibert, acting upon the same premises, devised an ingenious method of penetrating the membranes, so as to attack the microbes beneath, by using a syringe for the sub-membranous local treatment of diphtheria. The point of the syringe consists in a series of small hollow needles (like those of a hypodermic syringe), of sufficient length to penetrate the membrane, through which an antiseptic fluid can be brought into contact with the sub-membranous tissues. The weak point of this method is that the fluid comes into contact with the membrane only at that point at which the needle is inserted, so that merely a limited area of the tissues can be impregnated with the disinfectant. So long as surgeons are unfamiliar with any other than local germicidal methods, especially with a method of inoculation which will disinfect the system, a rational mode

of treatment can be reached only on the basis of the principles explained on page 68.

There is no doubt that protection as well as a kind of disinfection of the body—that is, artificial immunity against a series of infectious diseases—can be obtained, as shown in Section I., in various species of animals, toward the influence of different microbes. Some animals do not show any reaction at all toward certain species of microbes that are highly virulent to other animals; in other words, they are immune against them. For instance, rats and dogs are immune against the bacillus anthracis; men are immune against the cholera of chickens, erysipelas of pigs, etc. Such natural immunity is probably caused by the different chemical composition of the blood. As is well known, infectious diseases like measles, scarlet fever, and small-pox attack an individual only once, because the system, after having stood the disease once, becomes immune against a relapse of a disease of the same kind. Such immunity is called "acquired," in contradistinction to the one called "artificial," which has long been known. Indians and Chinese several thousand years ago rendered themselves immune against infection during epidemics of small-pox by inoculating themselves with the small-pox virus. They did it by scratching the skin-surface. They produced a slight infection with small-pox,

which infection protected them from acquiring the disease in its greater or original virulence; that is, they became artificially immune for a certain length of time against variola. The immortal merit of Jenner is that he utilized these facts methodically. In accord with the observations made after vaccinations with cow's lymph are the numerous experiments of Pasteur, Koch, Loeffler, Klebs, Chauveau, Roux, Wooldridge, Kitasato, Behring, Wernicke, and others, who tried to obtain artificial immunity of the system against certain infections by inoculations with the weakened virus of microbes. There can be no doubt that mitigated cultures of microbes are apt to prevent, or at least to diminish, the toxic effects of virulent microbes of the same kind under certain conditions. These facts Metschnikoff tried to explain by his theory of the phagocytes (compare Section I.), founded on the presence of substances called "phagocytes" which are hostile to the microbes. The white blood-corpuscles especially are supposed to possess this peculiarity, as they are of the same derivation as the mesoderma, and therefore have also a decided digesting power, which enables them to destroy microbes entering into the circulation. If these elements are not powerful enough to prevent the entrance of the microbes, the latter multiply in the individual and cause disease or death. When, by means of pure

cultures, Metschnikoff had inoculated guinea-pigs susceptible of infection with the bacillus anthracis, he found that the phagocytes would not destroy the microbes, while in non-susceptible animals of the same species destruction took place; when *mitigated cultures* were used, the phagocytes showed enough power to destroy the microbes, which had then lost a great deal of their virulence. By inoculating such animals repeatedly with mitigated cultures Metschnikoff at last succeeded in making them resistant to the most virulent cultures.

That the white blood-corpuscles really possess the power to destroy living microbes has been doubted; it seems to be more probable that they clean the tissues from dead organic particles by enveloping them.

Pasteur and Klebs advance the theory that after the first inoculation with mitigated cultures the greater amount of the substances which represent the soil of the microbes is consumed and not reproduced, so that cultures inoculated later on do not find an amount of favorable soil sufficient for their development and multiplication. Similar hypotheses were advanced by Chauveau, Salomon, Smith, and others.

As Buchner claims, the albuminous substances of the body exert bactericidal power, and he therefore advised the inoculation of susceptible

animals with the blood-serum of animals possessing natural immunity. The blood-serum of animals rendered artificially immune was finally utilized to produce immunity in other animals. Thus, Behring and Kitasato succeeded in producing immunity against tetanus in a manner similar to that by which vaccination immunity is obtained against small-pox. Recently, Behring, Wernicke, and Ehrlich discovered that the bactericidal capacities of the serum of animals rendered immune in the above-described manner can be utilized for sanative purposes. The curative power of the serum of immunized animals is supposed to depend upon its antitoxic influence upon the organism of the affected individual.

Good results from this new therapy are rereported in tetanus and typhus. The splendid results claimed by Behring, Wernicke, and Roux in the treatment of diphtheria are universally known and deserve the greatest attention. The effect and quality of the serum depend upon the degree of immunity which the immunized animal has reached, and which can be determined by the frequency with which the immune animal, without being killed, can be inoculated with the minimal dose of the virus deadly for normal animals.

To what extent the antagonism of some microbes can be utilized future experiments have

yet to show. For instance, the bacillus fluorescens putidus is a decided antagonist of the pus cocci and of the bacilli of pneumonia and of typhus; this is evidenced by the fact that if cultures of the bacillus fluorescens putidus are produced on gelatin, they will be non-susceptible for the implantation of the other microbes mentioned. Emmerich was able to save the lives of rabbits poisoned with anthrax bacilli by inoculating them with the cocci erysipelatis or with the bacillus prodigiosus or pyocyaneus. Fehleisen, by inoculating patients suffering from malignant tumors, especially from sarcoma, with the streptococcus erysipelatis, has repeatedly effected cures. The results obtained by Bull and Coley corroborate the importance of this discovery.

If thus bacteria are destroyers of bacteria, we should not give up hope of finding proper means of destroying septic microbes by inoculation also.

Injections with the toxines of diphtheria have been tried by the writer in a case of septicæmia, with apparent success. Toxine prepared by the writer from the blood-serum of septic animals also showed some effect in a case of septicæmia.

The discovery of practicable methods of carrying out the principles of general disinfection would certainly be well worthy of indefatigable investigation. It should, however, not be lost sight of that the effects in a test-tube are dif-

ferent from those obtained in the living organism.

Another point which renders disinfection by chemical substances impossible is the fact that some disinfectants prevent their own penetration by forming an impermeable stratum around the object of disinfection—such, for instance, as produce a layer of coagulated albumin around balls of sputa. Chemical disinfectants contend with similar difficulties as regards oily or fatty substances. Oil prevents all antiseptic agents, even bichloride, from penetrating tissues. It matters not if the disinfectants are dissolved or suspended in oil or are dissolved in water, or if the microbes are suspended in oil or in fat. The microbes are well protected by the layer of fat enveloping them, and there is no chemical substance strong enough to destroy the microbes by permeating this layer.

Other experiments (Schimmelbusch) have undermined confidence in the power of chemical disinfectants. There will be mentioned only the inoculation (anthrax) with septic substances of the distal end of a mouse's tail. No matter what the kind and the strength of the disinfecting agent used to disinfect immediately after inoculation, mice so treated died of sepsis, except when the tail was amputated within at most five minutes after infection. Richter found the bacillus

anthracis in the lungs, kidneys, liver, and spleen half an hour after such an inoculation.

It must, however, be borne in mind that these experiments do not, as a rule, correspond entirely to the conditions found in surgical practice, because they were made with pure cultures of highly virulent microbes. As noted in Section I., on the Influence of Microbes, the difference in the poisonous effects of the various microbes consists in their power of resistance against the tissues of the human body. Some of these micro-organisms multiply only in the juices of the body; others multiply only after having destroyed their soil or after having found a point of diminished resistance—for instance, a solution of continuity. Despite the great number of disappointing results of such tests, carbolic acid and bichloride of mercury are still most *en vogue* as disinfectants.

Carbolic acid (phenol), derived from coal-tar, has been known since 1834. No attention was paid to it until Joseph Lister made his revolutionizing experiments after studying its disinfecting influence upon sewage. For years, notwithstanding its great disadvantages, it occupied the front rank as an antiseptic before, during, and after all operative procedures.

Koch's researches showed that weak solutions of carbolic acid are incapable of destroying such

microbes as are of importance to the surgeon, and that even strong solutions were uncertain in their effects and required a comparatively long time to act. In full strength carbolic acid could not be used in those operations in which it would have been most desirable, such as laparotomy, etc. On account of the irritating effects of the drug, it could not be borne by so delicate a membrane as the peritoneum. Doubtless hundreds of patients, especially children and anæmic and cachectic individuals, have succumbed to the poisonous effects of this drug.

Accidents are often due to the careless use of carbolic acid by the public at large. Within the past year the writer was obliged to perform no less than seven amputations for gangrene of one or more fingers caused by carbolic acid. The patients, generally suffering from a trifling injury and knowing carbolic acid to be "a good wound medicament," buy a few cents' worth of the pure drug at the drug-store, where purchasers often are insufficiently informed as to its dilution. They add some water to it without mixing it well by stirring, and some of the injured parts come in contact with the pure carbolic acid; or they mix it well, but use too strong a solution. Consequently the tissues, as their fluid is taken out from them, shrink as they do in a burn of the third degree; the circulation becomes impeded,

and gangrene is the consequence. As local anæsthesia is caused by this process, the patient, unfortunately, feels relieved, and continues this treatment until the gray or black appearance of the finger calls attention to the great danger to which he has exposed himself. The writer has repeatedly seen and heard of similar accidents in gynecological practice, where the patient, instead of first mixing the carbolic acid in a pitcher or a basin, put the acid directly into her fountain syringe, added some water, and stirred it. The weight of the acid caused it to settle into the tube in its pure state, while the water in the bag contained only a trifling quantity of the acid; hence, naturally, when the patient introduced the nozzle of the irrigator into the vagina, the drug in its full strength came in contact with the mucous membrane and produced most extensive and dangerous destruction. The free sale of this drug should be prohibited by law. It is evident that Lister himself was well aware of these disadvantages, for he called carbolic acid "a necessary evil," which could not be dispensed with so long as nothing superior was presented.

Bichloride of mercury (hydrargyrum bichloratum corrosivum, corrosive sublimate) has been known for many centuries. Its use internally was recommended by Paracelsus. After Robert Koch and Theodor Billroth demonstrated its bac-

tericidal superiority over carbolic acid it was soon unanimously adopted by the profession, especially in consequence of the efforts of Bergmann, Schede, and others. Although it is at least as poisonous as carbolic acid, no surgeon would now care to do without it. But in connection with aseptic wounds it should almost exclusively be used to disinfect the field of operation and the hands of the surgeon. It cannot be employed for disinfecting instruments, on account of its destructive action upon metal. As a solution it should be used in combination with distilled water only; if ordinary water is used, the earthy substances (carbonic alkalies) of the water combine with the mercury, forming an insoluble combination (bi-, tri-, or tetra-oxy-chloride). To prevent this the addition of acids has been suggested. Fürbringer recommended salicylic, acetic, or hydrochloric acid; Laplace, tartaric acid; and Von Bergmann, chloride of sodium. As shown by Fürbringer, the influence of light and air is apt to impair the stability of a bichloride solution. A convenient stock solution, preferably 5 per cent., can be made by dissolving equal parts of corrosive sublimate and common kitchen salt in hot distilled water. Its influence upon wounds covered with pus or with blood is insignificant; hence, to obtain satisfactory results, the previous removal of such substances is essential.

Although the writer has used bichloride very extensively, under proper precautions, for a number of years, he has seldom met with alarming symptoms attributable to the use of mercury in infected wounds. Eczema and salivation and inflammation of the gums were repeatedly observed, but these symptoms disappeared promptly after the drug was discontinued. The writer has repeatedly employed a 0.05 per cent. solution to wash off fibrinous exudations of the intestine in peritonitis or in gangrenous herniæ, without having perceived any symptoms that could be traced to its use. It is of the greatest importance, of course, to protect the abdominal cavity with sterilized compresses, so as to apply the solution only to that part of the intestine lying outside of the cavity, and immediately thereafter to wash it off with sterilized water.

Chloride of zinc has been recommended by Billroth, Von Bardeleben, and especially by Kocher, the last named claiming that even so weak a solution as 2 : 1000 exercises a decided and all-sufficient antiseptic influence. This claim, however, has not been corroborated by other surgeons. The value of the chloride of zinc (a watery solution of 8 per cent. being preferable) seems to rest mainly upon its strong cauterizing qualities. Its good effect upon torpid ulcerations, fistulous tracts, etc. is unquestionable. The writer uses

it preferably on those ulcers for which nitrate of silver is ordinarily recommended, as the chloride exercises antiseptic as well as cauterizing effects.

Salicylic acid is made synthetically from carbolic acid, over which it possesses the great advantage of being much less poisonous. Only when in powder form and when placed upon wounds in large quantities has it really shown poisonous effects; but this advantage is somewhat counterbalanced by its weak antiseptic power, which can be increased by the addition of boric acid. The following is a desirable formula for that purpose:

Salicylic acid,	1 part;
Boric acid,	6 parts;
Water,	500 parts.

Where large wound-surfaces are involved, as in the case of burns or scalds, the writer found the salicylated gauze very useful (p. 124).

Aluminum aceticum, consisting of sugar of lead 25 parts, alum 5 parts, and water 500 parts, is used by Maas and Fischer for irrigation and as a moist dressing. It is prepared by slowly adding the sugar of lead to the cold solution of alum. It has also been particularly recommended whenever there are special reasons for apprehending poisonous effects from the use of carbolic acid or of bichloride of mercury.

Peroxide of hydrogen has recently been used extensively, and apparently with good results. Its precise value still remains to be determined, as the solutions generally used are not absolutely germicidal—a fact which can be proved by the experiments of Kyle, who found the tetanus bacillus growing in a 15-volume solution. Its main advantage lies in its power of destroying albuminoid elements, upon which the microbes multiply. Unlike bichloride, which is rendered powerless by albuminoid elements, hydrogen peroxide is especially useful in suppurative processes.

Pyrozone (aqua hydrogenii dioxidi), cortaining 3 per cent. H_2O_2 in permanent solution, possesses the same qualities as does the peroxide, but apparently to a somewhat higher degree.

Of the vast series of antiseptics recommended during the last decade, there may be mentioned thymol, natrium, borax, naphthalin, benzoic acid, zincum sulpho-carbolicum, terebene, eucalyptol, tinct. iodi, china, chloral, chloroform-water, permanganate of potassium, camphor, glycerin, citric acid, tar-water impregnated with oxygen, sulphuric acid, picric acid, resorcin, balsam of Peru, styrone, charcoal, powdered coffee, naphthol, aseptol, salicylresorcin, ketone, chromic acid, tannic acid, trichloride of iodine, creolin, pyoktanin, lysol, ichthyol, thiol, alumnol, turmerol, solveol,

iodol, salol, europhen, aristol, sulphaminol, sozoiodol (hydrargyrum sozoiodolicum), euphorin, formalin, and, last but not least, iodoform. Experiments made by the writer at the New York German Poliklinik with acetanilide, phenacetine, and phenocoll proved that these drugs also possess antiseptic qualities.[1] The limits of this volume preclude giving the characteristics of all these antiseptic substances. The selection of any one of them seems frequently merely a matter of choice.

Iodoform is the ideal antiseptic drug; despite all that may be said against it, it must be conceded that no equivalent for iodoform has yet been found. It is easily dissolved in alcohol, in ether, in chloroform, and in oils. According to G. F. C. Müller,[2] iodoform remains in an undecomposed state dissolved in all decoctions—with glycerin, in water and watery fluids, and in mixtures of the same kind if they are exposed to the heat of a sterilizing apparatus. Naturally, it remains suspended also in such mixtures if it is exposed to the temperature of the body. Iodoform incorporated in the system for the most part remains unchanged; this can easily be demonstrated in the urine of patients.

[1] "The Antiseptic Value of Phenocoll Hydrochlorate," *N. Y. Medical Journal*, March 19, 1893.

[2] *Aerztlicher Praktiker*, February 22, 1894.

No drug has ever been praised so highly and condemned so fiercely as iodoform. While hardly any surgeon was unconvinced of its antiseptic value, Kronacher, Fleyn, Rovsing, B. Tilanus, and others demonstrated that streptococci as well as staphylococci can easily be cultivated in iodoform powder. This led to the deduction that iodoform has no antiseptic qualities. But their conclusion manifestly admits of modification. Their experiments demonstrated only that iodoform has no *direct* influence upon microbes.

De Ruyter and Behring showed that iodoform renders products like the ptomaïnes (toxines) of certain microbes harmless by forming innocuous combinations with them; furthermore, a decomposition of iodoform by the microbes takes place, during which decomposition a bactericidal effect is exerted. Probably nascent iodine is set free during this process. The more advanced is the putrefaction, the more intense is the bactericidal action of iodoform; hence, although it has no active disinfecting power like that of bichloride of mercury, it is one of our most valuable medicaments, particularly as, besides its indirect disinfecting quality, it has the power of reducing secretion and of mitigating pain, and, in addition, exerts a decided antitubercular influence. (Compare Section XI., on Open-wound Treatment, and Section XIV., on Aseptic Injection.)

The writer recently used iodoform for other than antiseptic purposes. Having frequently noticed the excellent influence of an ethereal solution of iodoform upon cysts, lymphomata, goitre, etc., he used it successfully in hemorrhoids, varicocele, hydrocele, and varicose veins.[1] The splendid results obtained with the iodoform treatment after resection of tubercular joints and after extirpation of tubercular glands induced the writer repeatedly to use comparatively large quantities of iodoform in tubercular peritonitis. The striking manner in which the powder, as also the mixture, was borne by the patients led to the idea of using it also in general peritonitis. The injection of one ounce of a 10 per cent. mixture of iodoform and glycerin has repeatedly been made in general peritonitis, as also in cases where infectious pus escaped into the abdominal cavity during operation.[2] The writer does not claim any specific results for this treatment, which would be useless in acute septic peritonitis, but it is noteworthy that of five cases of suppurative peritonitis so treated, in which the chances of recovery were very poor, four terminated favorably. It cannot be proved, but it is conceivable, that the virulence of the pus—that is, the influ-

[1] "The Value of an Ethereal Solution of Iodoform in the treatment of Hemorrhoids," *N. Y. Medical Journal*, July 21, 1894.

[2] "Tubercular and Suppurative Peritonitis," *N. Y. Medical Journal*, April 21, 1894.

ence of the toxines—may be weakened by the co-absorption of the iodoform (see p. 255).

Whenever abundant discharges into the abdominal cavity may be expected, the writer usually dusts the site of operation with powdered iodoform; ordinarily it should be used only in connection with gauze, thus materially diminishing the danger of poisoning. But, although the writer has used iodoform most extensively during sixteen years, he never saw any serious symptoms traceable to its employment that did not promptly subside after its discontinuance. Some individuals have for iodoform a peculiar constitutional susceptibility, a real iodoform-idiosyncrasy, which manifests itself either in the appearance of papular or urticarial eruptions on the skin or in symptoms of brain- or heart-derangement, the latter generally by a frequent, small, irregular pulse. Besides these symptoms, disturbances of digestion and of the nervous system—headache, depression, debility, and sleeplessness—may occur. Anæmic or cachectic patients and aged individuals or infants, particularly if they suffer from heart or kidney diseases, should carefully be watched when iodoform is used on them, so that the symptoms of intoxication may be recognized at their earliest stage and readily be overcome. Undoubtedly, many cases of supposed iodoform-poisoning were really

septicæmic, some of those who reported such cases not being sufficiently familiar with the variable features of septicæmia—for instance, lacking the knowledge that the low temperature was sometimes characteristic of its most deleterious type.

If used in large crystals, the local effect of iodoform is more intense and enduring, and because of its slow decomposition the drug is less apt to be absorbed; it displays its main advantage, however, in the shape of iodoform gauze, the preparation of which will be shown in Section V., and its value and use in Section XI.

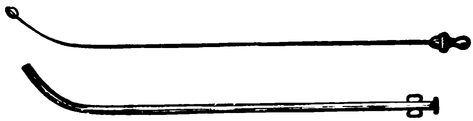


FIG. 20.—Beck's bladder-pistol.

Iodoform may be used in connection with collodion as a protection for wounds in which no secretion is expected. Its value as a suppository in connection with cacao-butter renders it useful in fistulous tracts and in hollow organs like the rectum and bladder. For the easy introduction of such suppositories or pencils the writer has devised his *porte-remède* (bladder-pistol; Fig. 20).[1]

The offensive smell of iodoform cannot be

[1] "Ueber intravesicale Behandlung, etc.," *New Yorker medicinische Wochenschrift*, March 3, 1889.

neutralized except by impairing its value. Tonka and coffee beans, which were highly recommended as deodorizers of iodoform, prove inefficient. If personal objection to the odor of iodoform prohibits its use, *aristol* and the non-poisonous *dermatol* are the most available substitutes.

It would be of great help, in determining whether any or what kind of disinfection should be selected, if bacteriology was sufficiently advanced to furnish information, during an operation, of the character of the infecting elements. The surgeon would then know better how to combat them. In some cases, however—for instance, in suppurative processes in the abdominal cavities, where specimens could not be obtained before operation—the writer has tried repeatedly during operation to get some information by the microscope as to the nature of the microbes.[1] Especially was a differentiation between gonococci, streptococci, and staphylococci desired. Bacteriological investigations—that is, making cultures—are of course out of the question during an operation; furthermore, the characteristics of microscopical slides of the microbes in general are not always so distinct that a positive differentiation by the microscope alone could

[1] Comp. *Transactions of the Eleventh International Medical Congress*, Rome, March 30, 1894. "On Tubercular and Suppurative Peritonitis."

always be made. But in reference to the most frequent abdominal operations—that is, to those indicated by suppurative inflammatory processes of the adnexa—valuable information can be gained by simple knowledge of the fact that, with very few exceptions, either streptococci, staphylococci, or gonococci are the originators of such inflammations. Other microbes need scarcely be considered, as the bacteriological investigations of Schauta, Wertheim, Menge, Prochovnick, and others have proved. The morphological features of the three cocci mentioned above, fortunately, are, unlike those of many other species, so well marked that they can almost always be differentiated by a microscopical examination alone. For instance, the other pyogenic cocci can easily be distinguished from the gonococci by passing a cover-glass preparation through the flame of an alcohol lamp and staining it by the method of Gram; while characteristics of the gonococcus are its peculiar shape, its size, and its being found within the cells. Another valuable point of differentiation is that as soon as gonococci are found the presence of streptococci or staphylococci can almost always be excluded. Such an examination, which, if everything has been prepared before operation, does not require more than a few minutes, would contribute to a decision of the question of disinfection. If the pus was

found to be either sterile or to contain gonococci, the abdomen could be closed and union by first intention would be obtained, while if cocci of greater virulence, such as streptococci or staphylococci—in a word, such cocci as are not gonococci—are found, disinfection and drainage should be employed. (Compare Section XI., on Open-wound Treatment.)

In cases like pyothorax or similar accumulations of pus, where aspiration of the pus can easily be done before operation, such investigation can be carried out by microscope and culture mediums. The great value of such bacteriological examination in diagnosis and prognosis is undoubted. In pyothorax, for instance, the presence of streptococci would point to the presence of solid masses, while pneumococci or staphylococci would indicate liquid pus. But such examinations do not yet possess such a degree of perfection as to be an infallible guide for the character of an operation for pyothorax.[1]

Manifestly, notwithstanding the great progress of the last few years, the methods of disinfection are still far from being perfect, and the main dependence is in prophylactic measures. Bacteriological researches have demonstrated that disinfection is not identical with the simple use of a so-called "antiseptic" agent, but that it re-

[1] "Pyothorax and its Treatment," *N. Y. Medical Record*, May 19, 1894.

quires a thorough knowledge of an entire series of fixed principles. The mastering of disinfection does not simply mean knowing the strength of an antiseptic fluid, but consists in knowing also the condition of the object to be disinfected, and the vitality of the microbes established in this object. Furthermore, there must be considered all the difficulties of disinfection resulting from dirty, oily, or fatty substances surrounding the object to be disinfected, and those that result from *chemical decomposition.*

The length of time required to disinfect an object is likewise of the greatest practical importance. There is no advantage in knowing methods by which a microbe can be destroyed by keeping it in carbolic acid for three weeks. In practice this knowledge is of no value, for the surgeon cannot wait; he requires his armamentarium disinfected within a very few minutes.

IV. PROPHYLACTIC DISINFECTION.

The old proverb which says that "an ounce of prevention is worth a pound of cure" might well serve as the motto of asepsis. Prophylactic asepsis—there is no other fitting adjective—rests mainly upon the disinfection of the surgeon's hands, of the instruments, and of the field of operation. As shown in Section I., the number of

micro-organisms on the outer surface of the body is legion, while within the tissues no microbes are found; therefore their removal from the surface of the body must be effected *before* proceeding to any surgical operation.

The hands and forearms of the surgeon are best cleansed according to Fürbringer's and Kümmel's methods, which depend more upon mechanical thoroughness than upon the choice of any special antiseptic. The skin must be brushed energetically with very warm water and green soap for three to five minutes, and then be dried with a sterilized towel. Scrupulous cleansing of the finger-nails with a small metal nail-cleaner is of the greatest importance. Not less than one minute, preferably longer, should be devoted to the nails. The writer has used Braatz's nail-cleaner (Fig. 21) with great satisfaction for several years. The

FIG. 21.—Braatz's nail-cleaner.

surgeon should have his nails cut short and rounded. Nail-files must be avoided, as they form irregular surfaces from which the microbes cannot so easily be removed as from a sharp cut done with scissors. The wearing of rings during an operation shows a misconception of

the principles of asepsis. Even if the rings be exceptionally clean, the little folds of the skin beneath them can shelter micro-organisms. After cleaning the finger-nails the skin must be rubbed for about one minute with a sterilized-gauze tampon dipped in pure alcohol (80 per cent.). This procedure is followed by washing and rubbing with a bichloride solution (1 : 1000) for another minute. If contamination with especially infectious material shortly before the operation was inevitable, the whole procedure recited above must be repeated. The entire process of disinfection should consume from five to ten minutes.

Howard A. Kelly[1] recommends washing the hands and the forearms with common brown kitchen soap for ten minutes, and then covering them with a hot saturated solution of permanganate of potash until they are stained a deep mahogany-red. After this treatment he advises that the hands be immersed and be moved about in a hot saturated solution of oxalic acid until all the permanganate is removed; they should then be dipped in milk of lime or in plain water to wash off the oxalic acid.

There can be no doubt as to the efficacy of both these methods, and the choice is simply a matter of taste. Disinfection does not depend upon one or another antiseptic, but is an art *per*

[1] *American Text-Book of Gynecology*, Philada., 1894.

se, and must be learned as such. A well-trained surgeon will clean his hands more effectively in one minute by brushing than a less experienced surgeon will do by using the whole *armamentarium asepticum* for hours. It is self-evident that after the hands have been washed the surgeon should not touch anything except aseptic articles, lest he reinfect himself before operation. If, however, non-aseptic objects have to be grasped, it is, to save the time for redisinfection, sometimes advisable to put on long sterilized gloves consisting of linen or of rubber dam. With the aid of such aseptic gloves all manipulations about the patient that are apt to be a source of infection can safely be done without the risk of contamination later on. As soon as the necessary preparations are finished, the gloves may be taken off and the hands be washed only in the bichloride solution.

It would be wrong, for instance, if, after having brushed the hands, the cork of the bottle containing the alcohol, or later on the vessel filled with bichloride, was grasped without having gloves on or without having those objects surrounded by sterilized gauze. To avoid this contact entirely the alcohol and the bichloride would better be kept ready for the surgeon separately in basins.

Braatz, assuming that in the cleansing process

the water required frequently to be changed, during which process the surgeon might be tempted to turn the spigot on or off with his hands, whereby contamination could easily take place, devised a pedal attachment for the spigot, such as is customary in many houses of the better class in Russia. A horizontal bar is substituted for the handle of the ordinary hydrant spigot, or the stop-cock of an irrigator is attached to a chain reaching down to near the floor, where a lever is attached to it. This lever acts as a pedal, pressure upon and release of which serve respectively to turn on and to cut off the water-supply. There is no doubt that such an attachment adds greatly to the comfort of the surgeon in a hospital; its absolute necessity, however, is open to discussion.

The skin of the patient must first of all be cleansed by one or several warm baths before operation. When virulent contamination has taken place, or if unclean individuals are handled, the *skin*, especially over the site of operation, should be scrubbed with ether after the second or third bath.

Before undertaking operations upon parts such as the *feet*, which, as a rule, are not washed regularly by most individuals, the thickened epidermis cannot be rendered sterile by following the principles of prophylactic disinfection for one

time only. There are legions of saprophytes and pathogenic microbes sheltered by such skin-surfaces, and a mere temporary influence of moisture is apt to cause them to develop and to multiply. Such parts must be prepared in the most radical manner. For at least three successive days there must be given a bath, which is to be followed immediately by a thorough scrubbing with a bichloride solution (1:500). The parts are then surrounded by a compress of aluminum acetate covered with oil silk. This application must remain *in situ* until the following day, when the bathing, scrubbing, etc. must be repeated. If these procedures are carried out for three days, the hypertrophied epidermis will become macerated and may easily be wiped off.

It is often advisable in preparing a patient for an operation, such as laparotomy, to cover the field of operation with a poultice of green soap on the evening preceding the day of operation, after prophylactic disinfection has been carried out. After the soap has remained for three hours it is scrubbed away, thus removing as much epithelium as possible. A towel saturated with a bichloride solution is then applied, and is allowed to remain until shortly before the operation.

The field of operation and its vicinity must invariably be shaved if there is the slightest evidence of the presence of *hairs;* the region must

next be scrubbed with soap and hot water, and afterward with alcohol and bichloride-of-mercury solution.

All operations in the vicinity of the *umbilicus*, especially laparotomy, require particular attention to thorough disinfection of the part. This disinfection is extremely difficult, and is sometimes even impossible. The folds of the umbilicus must be exposed as far as possible, and mechanical cleanliness must be observed to the utmost extent. Whenever the exposure of the folds of the umbilicus is difficult, the writer has found it useful to pour a teaspoonful of a saturated solution of iodoform-ether or of sterile iodoform-collodion into its grooves, thus covering and closing the dangerous folds.

Mucous membranes cannot be disinfected as thoroughly as the skin. Antiseptic solutions are not borne well, and they even irritate the mucous membranes, the absorbent power of which tends to intoxication, as clinical experience has repeatedly shown; furthermore, the effects of bactericides upon mucous surfaces, if not exerted permanently, are questionable.

Steffeck found that irrigating the *vagina* with a 0.1 per cent. solution of bichloride does not exercise the slightest destroying influence upon the micro-organisms of this organ; hence mechanical cleansing must be resorted to as the most

effective agent to the desired end. If an operation in the vagina is to be performed, the external genitalia must be cleansed in the manner described on page 95, and the hairs must be shaved. Then the vagina itself must be cleansed thoroughly with green soap and hot water. The whole organ must be wiped out energetically with a piece of gauze dipped in green soap, and afterward be wiped with gauze saturated in ether. Whether or not sterilization of the vagina and the uterine cavity by a steam-atomizer (like that of Von Farkas, p. 108), as recently recommended, can practically be carried out has still to be proved. The writer always found it useful to apply an ethereal solution of iodoform with a spray, as, in case the microbes have not thoroughly been destroyed, this solution will so cover the infectious area that the microbes will not come in direct contact with the wound to be made. The same procedures may be undertaken in other hollow organs.

No one claims to possess a safe means of rendering strictly aseptic the *rectum* or a *bladder* containing stones bathed in purulent urine; yet practically a great deal may be done in this direction. In operations on the rectum it is self-evident that laxatives should freely be given and enemas also be administered.

Tampons consisting of sterilized gauze, and

connected with a thread to make their subsequent extraction easy, should be introduced above the field of operation, to guard it against contamination by feces during the operation.

Medicaments, such as calomel, salol, etc., which would disinfect the contents of the intestine have repeatedly been recommended, but their efficacy remains still to be proved.

Thorough disinfection of the *bladder* is very difficult, and is often impossible. In a healthy bladder containing healthy urine no microbes are ever found, while in diseases of the bladder they are only exceptionally absent. Cazeneuve and Livon imitated retention of urine by constricting the pendulous portion of the urethra; after ligating the ureters they extirpated the bladder, extended by the accumulated urine, and preserved it in an incubator for a considerable length of time; nevertheless, decomposition, shown by the presence of micro-organisms in the exsected bladder, was observed.

The manner in which microbes enter the bladder is unknown. It remains to be proved that they can be brought from the kidneys. Undoubtedly, in the great majority of cases they are carried into the bladder by instruments used in surgical operations. Therefore none but perfectly aseptic catheters, sounds, etc. should ever be used. The special *modus operandi* of disinfect-

ing such instruments will be shown in Section V., in which their sterilization is described. A great impediment to the fulfilment of all the premises of asepsis is the *urethra*, which must be passed before the bladder can be reached. As Mannaberg, Rovsing, and Lustgarten have shown, the healthy urethra always harbors whole series of micro-organisms. Therefore it does not suffice to use sterilized instruments, but the urethra must also be cleansed before such instruments are passed. This cleansing of the urethra is very difficult, and uncertain as well. But it is the duty of the physician to employ his best endeavors, and he certainly can do a great deal by observing the following rules before introducing a catheter: (1) Clean the orifice thoroughly, after the principles expressed on page 95; (2) irrigate the urethra by the recurrent stream of an irrigating catheter. Boric-acid, Thiersch's or bichloride (1 : 25,000) solution, best answers the latter purpose.

Before operations on the bladder or urethra are undertaken, irrigations with bichloride (1 : 25-000) should be employed every five hours for several days, if possible. The urine may be disinfected to some extent by administering one or two drachms of salol within twenty-four hours of the operation. The same preliminary arrangements are required for operations on the *kidneys*.

Before operations on the *stomach* are undertaken, repeated irrigations of that organ are required.

Operations on the *mouth* require, first of all, mechanical disinfection—that is, the scrubbing of the teeth, etc. with sterilized gauze. It will often be necessary to use a nail-cleaner to scrape the teeth, and to brush them afterward with a tooth-powder such as the following: Pulv. oss. sepiæ, 70 parts; Pulv. rad. iridis Florent., 20 parts; Bicarb. sodæ, 10 parts. Then a solution of permanganate of potassium or of boric acid should freely be applied as a wash. The above-indicated procedures should be carried out, if possible, during several days; that is, the mechanical disinfection should be repeated at least twice a day, and the washing of the mouth every hour.

The *nose* requires little attention, as microbes are found in it only exceptionally. This fact explains the rare occurrence of sepsis even after the most careless operations upon this organ. At any rate, it should be cleaned repeatedly before operation with a 1 per cent. boric-acid solution.

Thorough cleansing of any part of the body implies the need of a good soap. In the writer's opinion, green soap (sapo viridis) is the very best for the purpose. There are some kinds of soap in the market, so made by careless manufacturers that the animal fat, impregnated with numberless

micro-organisms, has not been saponified by the application of heat. Thus, of course, infection with such a "disinfectant" would be possible.

The implements with which disinfection of the body or of any of its parts is secured deserve somewhat detailed attention here. The most important of these implements is the *brush*, which deserves much closer consideration than is usually given to it. Many surgeons who otherwise may be quite scrupulous do not hesitate to use, shortly before opening an abdomen, brushes that have lain in the dirtiest corner of the room. Some surgeons who appreciate the great importance of thorough cleanliness, and who doubt that a brush, after having been used once for removing purulent substances from the surface of the body, can properly be sterilized, advise their use only once. This limitation in the use of brushes proving expensive, small bundles of sterilized compressed wood-wool were devised as substitutes for brushes. These wood-wool brushes, being cheap, may be thrown away after the scrubbing. But it is evident that for the removal of tightly-imbedded filth from small folds, grooves, and edges of the body nothing can substitute a brush in efficacy; certainly such material cannot be dislodged with anything but a brush. Brushes —preferably those consisting of hog-bristles mounted in a back of wood—should permanently

lie in a bichloride solution. Should they come in contact with infectious material, they must be boiled according to the principles described in Section V.

The most indispensable factor in all the proceedings in disinfection is cleanliness in the application of the means by which it is attained. There should be attached to every wash-stand an enamelled box (Fig. 22) containing bichloride

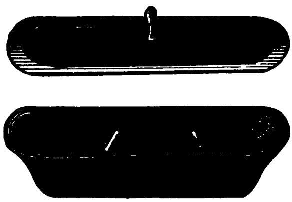


FIG. 22.—Enamelled brush-box (Lautenschläger).

(1 : 1000), in which the brushes may be placed after being sterilized. The solution must be renewed at least every twenty-four hours.

However, every attention to appliances, instruments, and dressings will prove futile if equally strict care is not taken by the surgeon *of his body*, particularly the parts which approach the patient. During operation a basin with sterilized water should always be within reach of the surgeon, so that he may frequently cleanse his hands. A well-disinfected brush should lie in each basin. Basins containing a solution of bichloride should

always be ready in abundance. The bichloride in such basins should be stained with fuchsin, so as to make it easily recognizable. Should contamination occur during operation, as from the bursting of an abscess, for instance, simple washing in this solution does not suffice, but the whole disinfecting procedure, as described in the beginning of this section, must be repeated, not only by the surgeon, but also by his assistants and by the nurses.

V. DISINFECTION OF INSTRUMENTS AND DRESSINGS.

The principle which occupies the front rank in Section IV.—namely, mechanical removal first of all—is of equal importance as regards cleansing the instruments.

Pus, blood-coagula, fat, and necrotic tissues adherent to instruments must be removed mechanically by washing with ordinary water. It is well to hold the instruments under the full stream of the hydrant while this washing is being done; then they must be put into hot water to which soda and soap are liberally added; in this fluid the instruments must be brushed energetically; then, after being washed again under the hydrant, they must be rubbed with sapolio or polishing powder, or some similar substance, and alco-

hol. A piece of leather should be used for this purpose. To be radical, washing in the soda-solution may then be repeated, and the instruments be dried thoroughly. Naturally, the instruments cannot be otherwise than absolutely *clean* after this procedure; but they still are far from being *sterile*, as is shown by Schimmelbusch's bacteriological examinations of instruments cleaned in this manner. After having dipped instruments thus cleaned into liquid gelatin he could always obtain cultures of microbes.

As stated in Section III., the most powerful and the promptest bactericidal agent is boiling soda-solution. Schimmelbusch proved that all pyogenic microbes die in a 1 per cent. boiling soda-solution in two or three seconds. Even the spores of the most resistant microbe, the bacillus anthracis, are killed surely in two minutes. This solution and an enamelled cooking-pot (Fig. 63) may be obtained everywhere. The size of the pot naturally depends upon the character of the operation and the amount of the paraphernalia required; as a rule, a pot about fifteen inches long, seven inches wide, and five inches deep is sufficiently large. Very long instruments are not generally used by the surgeon, but only by the obstetrician, for whose instruments a fish-boiler would be preferable.

Before the instruments are placed in the pot

they should be put into compresses or linen bags held together by safety-pins or bound together with a string, the ends of which can be squeezed in between the edges of the pot and its cover. The strings may serve as draw-strings by which the surgeon is enabled to lift the bag from the sterilizer. Naturally, the bag must be opened with well-disinfected hands only. To the boiling water in the pot is added pulverized soda—that is, the carbonate of sodium (Natrum carbonicum siccum, *P. G.*)—one tablespoonful to the quart.

FIG. 23.—Glass tray.

If this pure preparation cannot be obtained, ordinary crystallized soda must be taken, three tablespoonfuls to the quart. In this solution the usefulness (particularly the sharpness) of knives, which have to be boiled just as well as other instruments, will not be impaired, especially if they are put into the sterilizer on a separate frame, so as not to be in direct contact with the other instruments, especially those which have hard surfaces. If they are handled roughly and are

carelessly put into the basins, and if the blades are wiped off too forcibly, the cutting instruments—knives, scissors, sharp spoons, chisels, etc.—are soon ruined. Instruments having the so-called "French locks" require particular care around their joints. After the water has boiled for a few minutes the pot is placed in a basin containing cold water and there left until it has cooled. The instruments may then be taken directly from the pot, or they may be enveloped in a towel as described above, and be taken from the towel with sterilized forceps when required. In hospital the writer prefers to put instruments upon large, sterilized dry compresses covering the bottom of a thick tray of glass (Fig. 23), agate-ware, porcelain, or hard rubber, which can easily be disinfected by previous boiling in a soda-solution.

It is customary now to term such disinfection *sterilization*. As a rule, the term "disinfection" is applied to infected organs, cadavers, clothing, etc., while the term "sterilization" is applied to surgical instruments, culture-media, and fluids such as water, milk, etc. A sharp line of demarcation, however, is with difficulty drawn between these procedures, both tending to the same end.

Whenever blood, fragments of tissue, or any other substance adheres to an instrument, it must be cleaned mechanically in sterilized water.

Surgical instruments should consist only of *metal.* Their disadvantages are in being somewhat heavier than the old-fashioned wood- or bone-handled instruments and in their tendency to become slippery when wet with blood. The difference in weight, however, and the inconvenience above mentioned are compensated for by the facility of sterilization, which is practically impossible with the instruments formerly used.

FIG. 24.—Von Farkas' steam-atomizer.

Notches and grooves should be avoided, and carved handles should have places assigned them in museums. The construction of instruments should be as simple as possible, and no greater variety than is absolutely necessary should be employed. Automatic appliances should be avoided, and it should always be remembered that the hands, and not the instruments, of the

surgeon perform the operation. Schimmelbusch has shown that such simple instruments as probes and curettes carry very much fewer microbes than do complicated instruments such as scissors or forceps, which consequently require much more disinfection to render them safe for use. A well-trained surgeon is able to do a great deal of good work with the simplest instruments. If circumstances compel the surgeon to operate with wooden-handled instruments, his duty, at all events, is to boil them, and risk the possibility of the handle and the metal separating. If, however, glue has not been used in connecting the metal part of an instrument with its wooden handle, a short boiling does not affect the utility of the instrument.

Instruments with attachments such as *mirrors*, *electric lamps*, etc. cannot be kept sterile, but much may be done by careful mechanical cleansing. Their handles, however, can be so surrounded by sterilized gauze that contamination can be avoided. For sterilizing even so complicated an instrument as the cystoscope Nitze has recently devised an ingenious apparatus.

Rubber catheters can be made sterile by connecting their distal end with the mouth-piece of a steam-atomizer, Von Farkas' steam-atomizer (Fig. 24) being the most advisable one.

Nickel-plated instruments are not a necessity

nowadays, as the addition of soda to the boiling water prevents rusting. They are a desirable luxury, however, especially for instruments which are not in every-day use.

Instrument-cases should be so made that they may easily be cleaned. The best manner of preserving instruments is to keep them in cabinets composed of glass plates and iron. Tin is the best material for instrument-cases (see Section IX., p. 155).

Dressing material cannot be sterilized so easily as instruments. The generally accepted manner of sterilizing such material is by exposure to steam. The advantages of this powerful agent have been discussed in Section III. (see also p. 121).

If, in private practice, a sterilizer such as described below is not at hand, a fish-boiler may be used for the purpose of sterilizing the material, or, if even this cannot be obtained, a simple boiling-pot whose cover fits accurately may answer. If a stand made of iron or tin is inserted into the pot, it can be used for sterilization by steam also. Such stand should consist of a perforated disk resting upon three legs about three to four inches long (Fig. 25). This stand can be lifted by the holder reaching almost to the cover. The holder

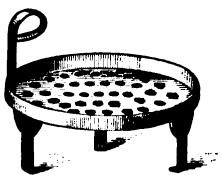


FIG. 25.—Beck's folding improvised stand.

and the legs may be folded together, and the stand then occupies such inconsiderable space that it can easily be carried in a bag among the instruments, etc. It is advisable to have two or three different sizes of stands at hand for private practice. The level of the soda-solution in which the instruments are boiled should be at least one inch below the disk, upon which the dressing materials, the towels, sponges, silk, etc. are placed. To facilitate free access of steam to the least permeable materials, such as towels, the writer finds it useful to place between them perforated tubes. As the instruments do not require as much time for sterilization as do the dressing materials, they may just as well be boiled in a separate pot (p. 291).

FIG. 26.—Koch's sterilizer.

While the simple boiling-pot is as effective for sterilizing dressing material as a more expensive apparatus, it does not, however answer the requirements of a hospital so far as convenience is concerned. The simplest apparatus of its kind is the sterilizer of Koch (Fig. 26), but the most approved one for such purposes is the one devised by Lauten-

schläger (Fig. 27). It consists of two copper cylinders, one inserted into the other, and both surrounded by a varnished linoleum cloak. The interspace of about two inches between the cylinders is filled with water to the middle of the apparatus, the level of the water being shown by the glass gauge attached to the external surface of the outer

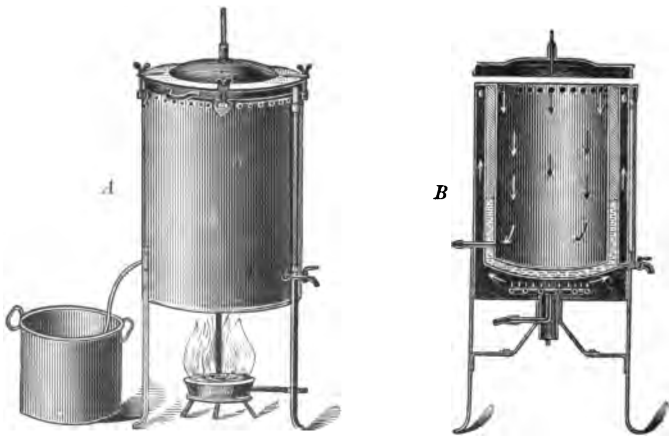


FIG. 27.—Lautenschläger's steam sterilizer for dressings (*A*, exterior view, *B*, cross-section).

cylinder. The steam, after rising into the small space surrounding the interior copper cylinder, passes through the holes of the upper part of the apparatus and enters the inner cylinder intended for the reception of the dressing materials. After placing the cover on the apparatus, the steam cannot escape upward, but passes through a tube

attached to the floor of the sterilization space; thence it is conducted through the coils of a lead pipe into a cooling-vessel containing water for condensing the steam. The cover, which fits hermetically, is fastened down by strong screws, a thermometer being attached to the centre of the cover. When the water is heated by gas or by alcohol the interior space containing the materials to be sterilized is heated before the steam enters. Thus, articles subjected to "pre-heating" (*Vorwärmen*, Schimmelbusch) are subsequently exposed to the steam. The time required for thorough sterilization of dressing material in this apparatus is forty-five minutes. In hospitals, where steam can be obtained from a boiler, the Lautenschläger apparatus is preferred. This apparatus, which has been used in the surgical wards of St. Mark's Hospital for the past three years, has given perfect satisfaction.

After the dressing materials, etc. are sterilized, it is of great importance that they afterward be kept so. The way in which sterilization is generally maintained is by keeping the materials in bags, baskets, cans, or boxes. The habit of many surgeons is to pick the dressing from its receptacle as required at the time of operation, and, placing it on the table, to cut such pieces as are needed. If this practice is followed, control of the nurses in charge of this work is absolutely

8

impossible. No matter how clean a table is, it certainly is not more sterile than an instrument-cabinet, even if the table consists of nothing but steel and iron. It is not conceivable that material kept or handled thereon can remain free from microbes. The safer way to obtain sterile material is to sterilize it in the apparatus *just before it is used.* To accomplish this it is best to keep the materials in a perforated tin box such as devised

FIG. 28.—Schimmelbusch's perforated tin box.

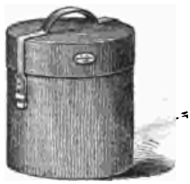


FIG. 29.—Schimmelbusch's tin box in a portable leather case.

by Schimmelbusch (Fig. 28), and to place the box in the steam apparatus before using the contents. The holes at the top are so arranged that they can easily be occluded by shifting over them a movable strip of tin. After having placed the dressing material, such as gauze and sponges cut into pieces, rolled bandages, etc. in the box the latter is put into the steam apparatus, the holes being open. After the box is taken out the holes are closed, thus rendering the box practically air-tight. There the sterilized articles may remain

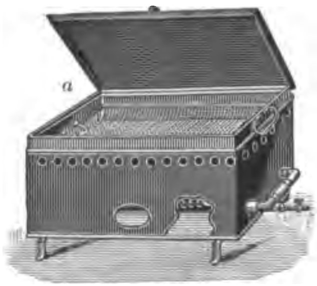
until they are required at the operation. In private practice such tin boxes may conveniently be carried in a portable leather case as devised by Schimmelbusch (Fig. 29).

Whether heating the material beforehand is really a necessity has, however, been doubted by many good authorities. It is true that it prevents moistening of the dressings, but moist steam has far greater germicidal potency than dry steam. If some care be taken in keeping the objects to be sterilized away from the interior walls of the apparatus, so that they do not come into direct contact with the water used for condensation, they will not become wet; but even should this occur, it will work no harm, being disagreeable only. As Von Esmarch has shown, steam is rendered less powerful when it is surrounded by gas produced by the heating process.

Recent investigations seem to prove "preheating" to be unnecessary, so that such complicated attachments as described above might be dispensed with. It is evident that the sterilizing process could thus be rendered much more simple and less expensive.

For the purpose of *sterilizing instruments* in hospitals, Schimmelbusch's apparatus (Fig. 30) seems to be the most desirable. Great stress is laid upon its hermetic occlusion by the cover, as the temperature of water boiling in an open

vessel is not equal in every part. The hermetic occlusion in Schimmelbusch's apparatus is obtained by a water-filling, which has also the advantage of preventing rapid evaporation of the soda-solution; were this evaporation not guarded against, refilling would be required whenever the apparatus was used for any considerable length of time. The burners must be so arranged that the flame can be kept as high or as low as may be desirable. The instruments are put into wire baskets (Fig. 30, *b*) provided with wooden han-



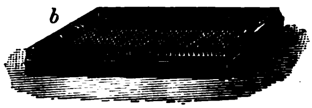


Fig. 30.—Schimmelbusch's gas-heated apparatus (*a*) for sterilizing instruments; *b*, wire basket.

dles to facilitate their being placed in and taken out of the apparatus. After the instruments are boiled in this apparatus for five minutes the wire baskets may be taken out and placed on sterilized towels or on vessels such as those described on page 107. It is optional with the surgeon to keep the instruments in sterilized water, in a solution containing alcohol, or in a solution of soda. Further sterilization is then unnecessary.

Numerous other useful sterilizing apparatus are recommended. The writer need mention only those devised by Körte, Schüller, Rotter, Straub, Mehler, Kronacher, Ostwalt, Arnold,

FIG. 31.—Braatz sterilizer (for dressings and instruments).

Meyer, Boeckmann, and Braatz (Fig. 31). Mally of Paris [1] advises a sterilizer in which glycerin can be boiled instead of water. Its advantage consists in the possibility of boiling metal, hard rubber, catgut, etc., as well as knives, without impairing their usefulness. The apparatus is constructed similarly to Braatz's dry sterilizer, mentioned on page 126.

For private practice it is convenient to have an apparatus which will allow simultaneous ster-

[1] *Zeitschrift für Krankenpflege*, No. 5, 1894.

ilization of instruments, dressing materials, etc. —so-called "universal sterilizers." In addition to the other requirements, such an apparatus must be portable.

For the past three years Körte's portable sterilizing apparatus (Fig. 32) has served the writer admirably. It is of such simple construction that it can be made to order by any tin-

FIG. 32.—Kōrte's sterilizer for dressings and instruments.

smith. This sterilizer consists of two compartments. The lower compartment may be used separately as a simple boiling-pot for instruments; the upper compartment, being destined for the reception of the dressing materials, may be attached to the lower part by merely placing it upon the lower one after having removed the cover of the lower division. The floor of the upper compartment consists of wire netting,

which allows free access of the steam produced by the boiling soda-solution. The top of the upper compartment is protected by a cover so arranged that by shifting it the steam can escape from time to time as may be desirable, according to the amount of pressure produced. In the upper compartment may be placed towels, dressings, sponges, and silk. Room may also be found for two operating-coats if made of thin material. This apparatus, which is heated by alcohol, the feeder being attached to its side, can easily be carried in a canvas cover.

The disadvantage of all these valuable apparatus, however, is their size, which makes it inconvenient to carry them to operations. Most operations require a sterilizer of considerable size.

FIG. 33.—Beck's folding sterilizer (*a*, apparatus folded; *b*, open).

Small apparatus, so-called "pocket sterilizers," permit only of the sterilization of a few sponges and the boiling of the instruments. To remedy

this defect the writer has devised a folding apparatus the separate parts of which can easily be put together (Fig. 33). The lower division (*A*), which is also the smallest one, consists of a reservoir which is half-filled with a solution of soda. A wire net on which the instruments are placed fits into this reservoir, which fits into the next division (*B*), which again fits into the larger division (*C*). If desirable, a fourth division can be set up. Wire sieves (*E*) can be inserted into the projections of the walls of division *B* as well as those of *C*, to receive the dressings, towels, sponges, etc. To the lower division (*A*) are attached two folding supports, between which, when in use, is placed the alcohol lamp (*G*). The lamp is so constructed as to allow of its being carried with safety when filled with alcohol. Besides the regular attachments—that is, the alcohol lamp, the wire sieves for the dressings, the wire net for the instruments, two hooks for pulling out the latter, and the thermometer—a few instruments, a silk-box, etc. find ample space in division *A*. After being folded together the height of the apparatus amounts to 6 centimetres. This height is less than one-fourth of that of the whole apparatus when ready for use, which amounts to 27 centimetres. The sterilizer can either be put into an instrument-satchel or be carried under the arm. Two quarts

of water after eight minutes will be so heated (as indicated by the thermometer fitted into an opening in the lid) as to fill the whole sterilizer with steam of a temperature of 100° C. (212° F.). Anthrax spores dried on silk ligatures showed no cultures after they had been exposed to the steam for fifteen minutes.

As has already been shown, the most valuable material for dressings and sponges is *absorbent gauze*, as it possesses all the elements of aseptic protection. Being a coherent material, it leaves none of its fibres in the wound; furthermore, it absorbs well and can easily be rendered free from pathogenic microbes. A great many substitutes for gauze have been advised; of these may be mentioned absorbent cotton, wood-wool, turf, moss, sawdust, white or black oakum, and bran; also chopped straw, tan-bark, ashes, sea-sand, etc.

The best material is not, as is generally supposed, the one that immediately absorbs the greatest amount of fluid, but it is that which absorbs *continually* and which is apt to *dry* at the same time. For instance, blotting-paper, although rapidly absorbing an enormous quantity of water, is useless as a dressing material, because its power of absorption ceases as soon as it is completely saturated with the liquid; moreover, it becomes softened, contractile, and impermeable like pasteboard.

The absorbing power of absorbent cotton, for which a great predilection seems to exist, is also small, and it cannot be compared with that of gauze.

The most desirable dressing material, next to gauze, is *compressed moss*, whose absorbent power is five times as great as that of gauze. Moss is a very soft and adaptable material, and it can easily be sterilized. It may be used either loose, after being put into gauze bags, or, preferably, compressed into a tablet-like shape. The writer for the last few years has also extensively employed moss-board as a splint. The board, after being dipped into water, adapts itself to the contours of the body like a plaster-of-Paris splint, over which moss-board possesses the great advantage of being absorbent and much lighter. It is indeed an ideal splint (Fig. 34), and in its thick size is especially valuable in compound fractures; for, should the discharges exceed the absorbent power of the gauze directly covering the wound, the moss splint takes up the superfluous discharge without impairing the usefulness of the moss as an immobilizing factor. After operations in the inguinal

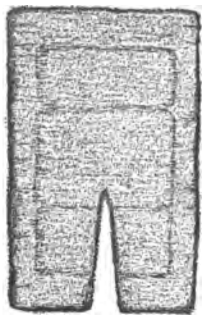


FIG. 34.—Moss-board.

region it immobilizes excellently for protecting the abdomen and thighs, if cut in the shape illustrated by Figure 34. It also dries constantly while absorbing at the same time. It may further be remarked that the price of moss-board is very low. On further indications for the use of moss-board see page 195.

For protecting *aseptic wounds* common *absorbent gauze*, if properly sterilized, is sufficient; for the treatment of *infected wounds*, as will be noted in Section X., gauze must be impregnated with an antiseptic substance, such as iodoform, salicylic or boric acid, etc.

Iodoform gauze is prepared best by dusting the well-pulverized iodoform powder over the common absorbent gauze and then rubbing it into the meshes, by means of sterilized gauze mops, until the gauze has assumed a yellow color. It is, of course, much more convenient to prepare iodoform gauze by simply dipping it into an emulsion of glycerin or into an ethereal solution of iodoform; but the addition of glycerin seriously impairs the power of absorption, and gauze impregnated with an ethereal solution decomposes easily.

Iodoform gauze may, after being rolled up in a piece of gauze, be sterilized in steam. Sterilization should, however, not be kept up longer than is absolutely required, as decomposition

may be caused by it. The gauze may be preserved in sterilized jars, but it is preferable not to keep a large stock, but to prepare it anew as required. A strength of 10 per cent. is generally sufficient. It should be borne in mind that the higher the percentage of the iodoform, the weaker becomes the absorbing power of the gauze.

The indications for the use of iodoform gauze will be described fully in Section X., on Treatment of Infected Wounds, and in Section XI., on Open-wound Treatment.

Gauze can be impregnated with almost any antiseptic drug. Besides iodoform gauze the writer uses only *salicylated* or *dermatol gauze*, and this only when a substitute for iodoform gauze is required—as, for instance, in the event of the occurrence of eczema, which may sometimes be produced by the use of iodoform (see pp. 86, 227).

Salicylated and dermatol gauze is made up reliably by most druggists.

Bandages should be kept in stock in large quantities. They can easily be sterilized in steam. Various lengths and widths are required, and they should consist either of common absorbent gauze, of starched gauze, or of Canton flannel.

VI. STERILIZATION OF CATGUT, SILK, ETC.

With the advent of the aseptic era the desire for absorbable sutures and ligatures was naturally more strongly developed than ever before. Rhazes in 1813, and later Hennen, Young, Lawrence, Astley Cooper, and Dupuytren, had sutures made of an organic material consisting of leather or of gut, but their experiments did not prove very encouraging. Joseph Lister established the repute of gut by claiming that after its disinfection in carbolic acid it admirably serves its purpose without being a source of infection.

There can be no doubt that catgut is one of the most desirable materials in surgery, and nothing has yet taken its place. It would indeed be "the ideal suture" but for the objection presented by the great difficulty it offers to sterilization. More than one hundred methods have been advised, but the great number offered is always the best proof of the weakness of each. Raw "catgut," as ordinarily obtained commercially, is infected with the microbes of its source—namely, the submucous coat of a sheep's intestine; furthermore, it contains much fat. The latter may easily be removed by soaking the gut for forty-eight hours in ether, but it still remains to be proven whether the microbes in catgut can be destroyed with absolute certainty.

Of the many sterilizing methods advised and most extensively used, there may be mentioned the following: After the fat has been removed by immersion in ether the gut is soaked in an alcoholic bichloride solution (1 : 100) for forty-eight hours and is then preserved in alcohol.

FIG. 35.—Braatz's metal box for sterilizing and keeping catgut sterile.

Another method, which is deserving of more confidence, is to boil the catgut in alcohol. This is done by putting the catgut in a strong glass bottle containing alcohol. After the tightly-closed bottle has been kept in boiling water for fifteen minutes the catgut is assumed to be sterile, according to bacteriological examinations on artificial soil made of catgut so treated. The chance of the catgut being well sterilized is increased by repeating the boiling process on several days in succession.

Braatz[1] devised an apparatus (Fig. 35) which,

[1] *Die Grundlagen der Aseptik.*

he claims, renders catgut absolutely sterile, useful, and durable. After having extracted the fat from the gut with ether, he winds it on metal rolls. These rolls are placed in the metal box, whose cover is hermetically closed, so that no dust can enter. The amount of catgut needed only at one time is drawn through a small hole in the side of the box and is cut off; thus the catgut remaining in the box continues uncontaminated, and

FIG. 36.—Braatz's apparatus for sterilizing catgut.

therefore sterile. When it is proposed to sterilize catgut the metal box containing it is put into the dry sterilizer (Fig. 36). The catgut can also be preserved in the same box in which it has been sterilized. The principle of the operation of

Braatz's apparatus consists in the fact that one wall of a flat metal box filled with liquid paraffin lifts and lets fall a cone with the fall and rise of the temperature in the apparatus. The supply of gas is thus automatically regulated, keeping a uniform temperature, which is supposed to be an important point in dry sterilization.

A much favored way of preserving catgut in alcohol is to keep it in glass jars having hard-rubber caps (Fig. 37). The writer, however, prefers to use the metal box (Fig. 42), devised by himself, which is a modification of Braatz's and which can also be used for silk (see p. 136).

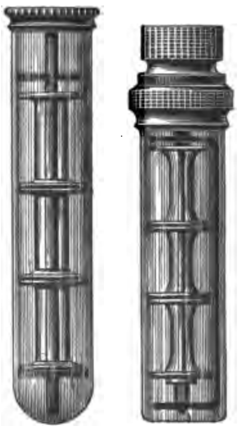


FIG. 37.—Glass jars for catgut.

But even when cultures could not be obtained from catgut prepared in the above manner, suppuration resulted from its use, as reported by Kocher and Klemm. Klemm used catgut sterilized in bichloride and alcohol, and kept it in alcohol for several weeks. With sterilized scissors he cut several small pieces of this gut and placed them on different soils—namely, on peptonized gelatin, agar-agar, and bouillon. The soils thus inoculated were observed in ordinary

temperature as well as in an incubator kept at a constant temperature of 98° F. No cultures appearing in three weeks in the test-tubes nor on the Petri plates, the catgut was deemed sterile; it was then used in operations such as amputations, herniotomies, etc. Notwithstanding the strictest aseptic precautions, it was repeatedly found that locally as well as generally everything appeared normal during the subsequent five or six days, but between the seventh and tenth days there occurred a slight elevation of temperature. The vicinity of the wound became swollen and red, and upon separating its edges there was revealed the presence of a deep-seated abscess. It was clearly evident that suppuration had taken place around the catgut sutures; while in the skin, where silk was used, no suppuration was discovered. It was then deemed possible that infection had originated from the centre of the catgut suture. As absorption of the catgut begins at its periphery, it might be assumed that microbes locked in the centre of the gut were set free when absorption reached that part of the suture. This would be in harmony with the fact that signs of suppuration generally appeared a week after the insertion of the sutures. To ascertain the correctness of this assumption slices of catgut prepared in the manner previously described were pulled into small pieces by steril-

ized pins and put on the same soil, but the result was negative.

The following experiments were also made by Klemm at the surgical clinic in Dorpat, where, so long as silk was exclusively used, suppuration was only exceptionally observed:

A number of cats, toward whom the same strict aseptic precautions were observed as is done in operations upon human beings, were treated by making in both thighs long incisions reaching down to the muscular tissue. A medium sized sterile catgut suture was implanted in the wound of one thigh, while a silk suture was buried in the other: four days later the animal became weak, refused nourishment, and died a few hours after the first symptoms of infection appeared. Where the catgut was implanted nothing abnormal was observed on the superficies, but after opening the united edges of the wound there escaped a brownish liquid of an offensive odor. The cellular tissue was also discolored and œdematous.

After having exposed the muscular layer into which the catgut was implanted, and which showed the same change, the catgut was found sodden, of an offensive odor, and of a reddish-brown color. The silk implanted into the other thigh presented nothing abnormal. The fragments of catgut, as well as those of the silk,

were removed with sterilized instruments and put into separate Petri plates filled with gelatin. Two days later the plate containing the catgut fragments showed a rich colony of pathogenic microbes, while the one with the silk proved sterile. These experiments caused Klemm to maintain that, while catgut may be sterile, it is a favorable soil for the establishment of micro-organisms. It is an organic membrane, and under the influence of moisture and warmth it is very prone to decomposition should it come into the slightest contact with micro-organisms. As the normal tissues of the body shelter no micro-organisms, the theory was advanced that they reached the catgut through the air, and that in connection with this material the possibility of infection from the atmosphere was greater than was attributed to this source. At any rate, the action of chemical reagents in test-tubes may be prompt, while their action is questionable upon micro-organisms within a wound. *A wound has no dead soil, as has a test-tube containing gelatin.* Furthermore, test-tube experiments must needs differ from the conditions found in a wound, where the micro-organisms encounter living tissues. It is still an open question whether Klemm's and Kocher's experiments demonstrate the propriety of discarding a material that offers such decided

advantages as does catgut. It is possible that the catgut of these experimenters was infected, despite all the precautions reported, and that greater care, as well as sterilization by heat, would perhaps have rendered it just as safe as silk.

Be it as it may, the above experiments show that sterilization of catgut requires such great care as to prevent a considerable number of surgeons from using it altogether, or at least intraperitoneally. The great fear of imperfect sterilization—a fear strengthened by reports which traced suppuration and even death to the use of catgut—induced the writer to forego the use of this material, to his great regret, in operations where concealed sutures are used—that is, just where catgut displays its most desirable quality. If after an abdominal section the abdomen be closed, the site of an infection caused by a catgut ligature cannot be discovered at a period early enough to allow of effective disinfection; while if used on the skin surface only, the symptoms of infection from catgut are so early perceived that by such procedures as immediate removal of the infectious material, opening of the wound, etc. general infection may be prevented. In operations on the surface, however, the only advantage possessed by catgut over silk consists in the fact that removal of the sutures is unnecessary after they have served their purpose. If, as may con-

fidently be expected, an absolutely reliable method of sterilization is invented, catgut will represent the most perfect ligature material.

Silk can very easily be sterilized by winding it on glass spools and boiling it in a soda-solution for at least five minutes. Silk is used in various sizes, according to the vessels or pedicles to be tied. As it can be boiled with the instruments just before it is required, the question of its preservation in a sterile condition is unimportant. In hospitals, bottles with ground-glass stoppers and spools on glass racks (Fig. 38) are frequently used to preserve sterilized silk. Some surgeons prefer to keep it in test-tubes stoppered with rubber corks which may be carried in an aseptic suture-case

FIG. 38.—Ligature-bottle with ground-glass stopper, and one spool on glass rack.

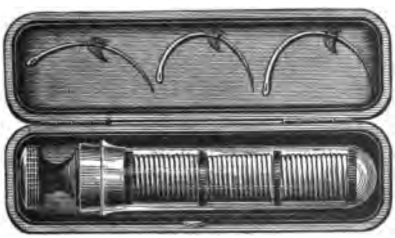


FIG. 39.—Aseptic case for silk sutures.

(Fig. 39). Others prefer to keep silk on reels of polished plate glass (Fig. 40) which can be carried in sterilized paper or linen or in small metal boxes.

Schimmelbusch[1] recommends sterilization of silk in steam. The silk threads are wound on rolls attached to a metal box (Fig. 41), which is put for three-quarters of an hour in the sterilizer, where it can be sterilized with the dressings, etc. Silk remains sterile and dry in these boxes. The fact that it is dry materially facilitates threading it into needles and tying.

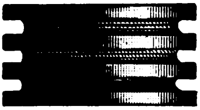


FIG. 40.—Reels of polished plate glass with three cuts for various sizes of silk.

The writer has devised a metal box which, by combining the advantages of Schimmelbusch's apparatus for silk and that of Braatz for catgut, can be used for sterilizing and preserving catgut as well as silk (Fig. 42).

Silk is certainly the safer material, and it is far preferable for ligating large blood-vessels, in which operation too early absorption of a catgut ligature might prove fatal. Although silk is not absorbed in the majority of cases, if strict asepsis has been observed it will be encysted, and thus practically fulfil the same requirements as though it were absorbed. It, furthermore, has the advan-

[1] *Aseptische Wundbehandlung.*

tage that even thin silk may be used for the ligation of large blood-vessels. The impossibility of using catgut in delicate plastic operations, in which only the thinnest kind of silk is advisable, makes the latter exceptionally useful for this special purpose.

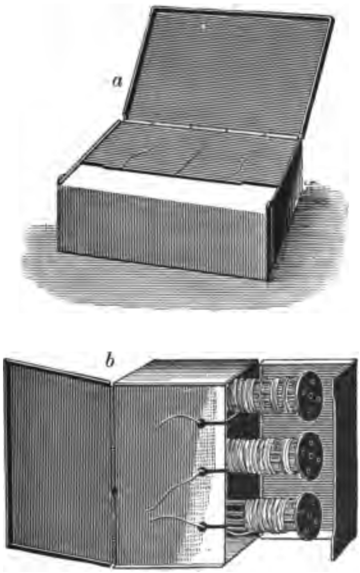


Fig. 41.—Schimmelbusch's metal boxes for sterilizing silk and keeping it sterile (*a*, box closed; *b*, box open).

Recently, simple *thread* has been recommended as a substitute for silk, on account of its lower price and because it can be sterilized as thoroughly as silk. But silk can be handled better and can more easily be tied.

Silkworm gut, which is furnished in bundles like the reels used by anglers, can very easily be sterilized. Some surgeons favor silkworm-gut because of its smooth surface and its density,

FIG. 42.—Beck's metal box for sterilizing and preserving catgut and silk.

deeming it on this account the least irritating of sutures.

Silver wire may quickly be sterilized in boiling water. It is not at present so extensively used as formerly, when silk was not so easy of sterilization. The writer still finds it very useful for sewing bone-fragments and for "buried sutures" in operating for ventral hernia. It may also be used in plastic operations as a relaxation-suture or as a prophylactic suture (see p. 166).

The use of parchment sutures, of threads made of the aorta of the ox, or consisting of horse-hair, kangaroo-tendon, etc., is merely a matter of choice.

VII. SPONGES, DRAINAGE-TUBES, AND IRRIGATION FLUID.

Sponges.—There can be no doubt, from a strictly technical standpoint, that ordinary marine sponges, such as are generally used, are the best material for the purpose of sponging, being elastic and possessing immense absorbent power. Their sterilization, however, is very difficult, if not uncertain. The safest method of sterilizing sponges would be by boiling in a soda-solution for ten minutes; but as this procedure materially reduces their elasticity, and as shrinkage hardens them, their usefulness is much impaired by such sterilization. Schimmelbusch therefore advises the following method: Sponges, as ordinarily purchased commercially, are freed from dirt by beating out the sand and shells in their alveoli. They are then soaked for several days in cold water slightly acidulated with muriatic acid, and are kneaded from time to time. They are then washed thoroughly, first in cold and then in warm water, until the water remains clear. They are then enveloped in a linen sheet and put into

a boiling 1 per cent. soda-solution. To limit shrinkage while boiling, it is advisable to take the boiling solution from the fire shortly before the sponges are immersed. After remaining in this hot solution for thirty minutes they are squeezed out and freed from the soda by again immersing and squeezing them in boiled water. They may then be kept in a ½ per cent. bichloride solution.

Regarding the uncertainty of sterilization, careful surgeons do not care to use marine sponges after they have come in contact with infectious material. But to discard sponges after having employed them only once is extravagant, considering their price; it is quite natural, therefore, that most surgeons have given up ordinary sponges, and in their stead use only small sterilized gauze mops, which admirably answer all the purposes of sponges.

As tampons in hemorrhages and for operations on the mouth and the pharynx, marine sponges are of considerable value, especially when fastened to a sponge-holder. The writer during the past few years has been satisfied to operate without using a single marine sponge during operation, as the fear of insufficient sterilization outweighed all other considerations.

Gauze used for ordinary surgical dressings may be sterilized according to the methods de-

scribed in the previous section. If kept in the steam of a sterilizer for thirty minutes, the most resistant spores in it will be killed. *Mops* may be made of a number of folds of gauze loosely hemmed at the edges. They should be so cut as to preclude the risk of leaving loose threads in the wound. For the abdominal cavity gauze pads from six to ten inches square are useful. The greatest advantage of this material is that after being used it may be thrown away, its cost being insignificant. Small bags filled with moss or with wool may serve just as well, and they are somewhat cheaper. A supply of such mops may always be kept in a glass jar, but it is preferable to sterilize them shortly before they are used.

Drainage-tubes seem to be almost as near the stage of surgical extinction as are sponges. Nothing characterizes the lukewarm aseptic surgeon more than his predilection for drainage, which, in fact, means nothing less than that he lacks confidence in his own system of asepsis. If, on the one hand, no antiseptic irritants have been used during operation, if all aseptic precautions have been observed, and if no wound-pockets have been left, discharge from the wound is practically *nil*, consequently such a case will not give rise to anything that needs to be carried off by a tube. On the other hand,

if operations in infected or suppurating areas are to be performed, drainage will be a necessity, but even then it should not be effected by rubber drainage as a rule, but by gauze packing, as shown in Section XI., on Open-wound Treatment (pp. 190 and 218). Still, surgeons cannot entirely do without drainage-tubes where neither union by first intention is to be expected nor thorough packing with gauze is to be performed. The most desirable tubes, then, are those made of soft India-rubber. They must be as wide as possible, and they should be fixed at the most dependent part of the wound. They may be fastened in the wound either by sewing them to the skin or by transfixing one end of the tube with one or two safety-pins. It is perhaps needless to say that the pins must be boiled in a soda-solution before use. Holes should be made in the sides of the tube at short intervals, and the tube should be cut off nearly flush with the skin.

Rubber drainage-tubes can easily be sterilized by placing them for five minutes in boiling soda-solution. This length of time suffices for the destruction of all microbes. If the rubber be kept in the solution much longer than five minutes, its usefulness will be impaired. In steam, rubber drains require at least twenty minutes for sterilization. After being made aseptic the tubes may be preserved in a 5 per cent. solution of

carbolic acid. Bichloride is not be recommended, as it forms chemical combinations with the rubber. The best plan, however, is to boil the tube in a soda-solution just before use.

Tubes consisting of *glass* or of *hard rubber* can easily be rendered aseptic. On account of their rigidity they are preferred by some surgeons, who claim that soft-rubber drains may be compressed in the wound, thereby causing retention of discharges. The writer has never in practice experienced any retention of pus which could be traced to compression of a soft tube. Whenever retention really occurred, it generally was due to obstruction in the tube, caused by thick or coagulated products of the wound or by other causes (see Section XII., on Change of Dressings). It seems to the writer that the pressure exerted upon a wound-canal by a hard drain is apt to cause sloughing. A great disadvantage of hard drainage-tubes is that they cannot be cut into proper lengths, as can those consisting of soft rubber, consequently a large variety of lengths of hard tubes must be kept on hand.

Drains of *decalcified bone* are scarcely used at present. They are unreliable and are often too quickly absorbed. *Catgut*, *silk*, *thread*, *wick*, *horse-hair*, and *threads of spun glass* are used for very small drains ("capillary drainage"), the most

valuable among them being the wicks, which can be made from ordinary lamp-wicks. The indications for the various forms of drainage, and its technique, will be described in Section X., on The Treatment of Infected Wounds, in Section XI., on Open-wound Treatment, and in Section XII., on Change of Dressings.

Schede recommended the utilization of the *moist blood-clot* which forms in cavities left after a piece of bone has been removed. He unites the outer edges of the wound above the cavity after it has filled with blood. If aseptic precautions are taken the blood-coagulum remains aseptic and will gradually be absorbed. The clot affords protection to the raw surfaces of the wound, and if it does not contract and desiccate it forms a nidus for granulation-tissue, which develops and finally cicatrizes. It is an ideal method of repair, especially in operations for the removal of necrosed bone without requiring a drainage-tube.

Irrigation Fluid.—Sterilized water only must be used for the washing of wounds or the skin of the patient, and the surgeon should wash his hands in no other liquid, be it mixed with an antiseptic or not. The fact that underground water is always sterile, showing the efficacy of filtration, has led surgeons to imitate nature by selecting artificially sterilized water for sur-

Aseptic operating-room, St. Mark's Hospital, New York.

gical purposes. But no apparatus constructed on the plan of natural filtration will furnish absolutely sterile water. As indicated in Section III., boiling water is the most powerful disinfecting agent; anthrax spores exposed to it for only two minutes are invariably destroyed. Therefore water which has been boiled for five minutes may safely be considered sterile. It is best to prepare such water shortly before the time of each operation. The water may be preserved, however, if, after being boiled, it is kept in clean glass vessels stoppered with sterilized cotton. In large hospitals it is advisable to have a special apparatus for the sterilization of water. A simple boiler in which water can be boiled and then quickly be cooled by a system of water-pipes containing cold water admirably answers the purpose. Water from deep wells, however, is generally aseptic, while stagnant water is loaded with microbes.

VIII. THE ASEPTIC OPERATING-ROOM.

The *operating-room of a hospital* (Pl. V.) should be at a considerable distance from the wards, to avoid as much as possible disturbance to the ward patients. The most preferable place is the top floor, as, besides the convenience mentioned, good light can be obtained there. It is a great conve-

nience to have two smaller rooms adjacent to the operating-room—an anæsthetizing room (Pl. X., Fig. 2), and another room in which the surgeon and his staff can dress and disinfect themselves. It is also desirable to have a store-room for the materials required at operations. The main requirement of a strictly aseptic operating-room is that its floor, ceiling, and walls may easily be cleaned. All the objects in the room should serve none but surgical purposes, and should be simple and plain. They must be able to withstand either energetic scrubbing or boiling in a soda-solution. The floor must easily be drainable and be waterproof. Terrazzo or marble is the best material for flooring. The walls should be cemented, or at least be oil-painted, and the corners of the room should be rounded, so that washing is easy.

On one side there should be several *wash-basins* supplied from hot- and cold-water spigots, so that either hot or cold water may freely be used. The basins should be large enough to permit immersion of the hands, forearms, and elbows. Arrangements should be made to have the water-supply of the pipes sterilized before it escapes from the spigots (see p. 142). A wash-sink (with a copious water-supply and with drip-stones nearby for dishes), sterilizers, and vessels for boiling water and soda-solution,

preferably seated on a wash-stand (Fig. 43), are also required.

Neuber advises that there should be attached to the walls large *glass shelves* on which glass bowls may be placed and into which bowls the water may run. Glass shelves are desirable at

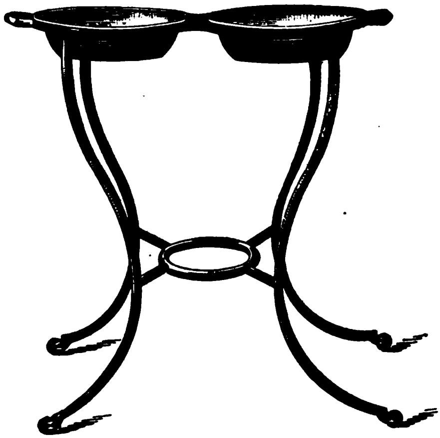


FIG. 43.—Simple wash-stand for two enamelled dishes (frame wrought iron, white-enamel finish).

all events to hold the glassware, sponges, gauze, drains, ligatures, cotton, etc.

Much has been said about the danger of *spectators* being present in an operating-room. Some surgeons allow the presence of spectators only after they have given assurance that they have not shortly before attended any case of contagious disease; other surgeons demand certain

precautions from spectators—as, for instance, that they shall put on aseptic coats; and some surgeons do not admit spectators at all. There can be no doubt that the fewer the persons there are in attendance the better it is for the patient; at the same time, it is in the interest of humanity that students be admitted, as the necessary experience can be acquired only by their presence as frequently as possible at surgical operations.

That spectators may carry microbes into the operating-room on their clothing and their bodies cannot be doubted. After having attended pathological rooms, such as sick-rooms or even autopsy-rooms, pathogenic microbes must abundantly adhere to the clothing, the hair, etc. If this clothing comes into contact with an object to be used at the operation, all aseptic precautions previously taken may prove to be valueless. The patient himself may carry microbes on his body, in the wound, or on the dressings. If the patient's dressings be changed, fibres of gauze or of cotton or scales of epidermis may be set free and be disseminated in the air, eventually to settle upon some one's clothing. Furthermore, when windows are kept open a considerable amount of dust containing organic substances from the excretions of animals may invade the room, and settle upon an object which may come into contact with a wound made or to be made.

Neuber, one of the most distinguished pioneers of aseptic principles, considers the arrangement of the operating-room to be the main requisite for success. He lays great stress upon having separate operating-rooms—one at least for septic and one for aseptic cases, each possessing separate furnishings and supplies. There can be no doubt that it is desirable to have at least two operating-rooms, and to have the arrangements made in the manner described above. Although much may be said in favor of Neuber's theories, they cannot be sustained in practice; and, fortunately, the recent investigations of Petri and Cleves-Symmer prove that they are not the sole essentials of success.

Petri not only fixed the special forms of micro-organisms suspended in the atmosphere, but at the same time he also ascertained the number of microbes present in a determined volume of air. His method of determining the *presence of micro-organisms* consists in pumping a measured volume of air through a filter of sterilized sand. This sand (to which all the micro-organisms of the air adhere) is equally distributed on Petri plates containing sterilized gelatin. On this gelatin the microbes multiply by forming as many separate colonies as there are microbes, which may then be counted.

The next question to be determined is that of

the *number of microbes* which will settle within a fixed time upon a wound-surface of a certain area. In determining this question a parallelism could not be assumed between the microbe-capacity of the air and the quantity of the deposits. It would naturally be expected that air containing but few microbes would deposit but few upon wounds, and *vice versa*. But it has been shown practically that this parallelism does not always exist, as most probably the microbes are not equally distributed in the air, some regions being densely and others sparsely populated. This fact can best be shown, according to Cleves-Symmer, if several gelatin plates are exposed at the same time and the different plates are kept in the same part of the room. A great difference as regards quantity and quality will then be found, for neither the same kind nor the same quantity of microbes will settle upon the plates.

Cleves-Symmer exposed gelatin plates for seven days simultaneously in three surgical wards. This exposure was made five times a day, the first at 5 A. M., while the patients were asleep, and the second at 7 A. M., after the floors were first washed and then scrubbed. Similar exposures were made at 9 A. M., when operations were generally performed, and the last exposure was made late in the afternoon. The sterile gel-

atin was contained in round, flat, large-surface Petri dishes. After the dishes had been exposed each time for twenty minutes they were covered and preserved in a moist incubator the temperature of which was that of the room. The developing colonies, as soon as they could be recognized by the naked eye, were counted daily, and were observed so long as they could be distinguished from one another. Among 4613 microbes so counted there was found but one pathogenic micro-organism, which was the bacillus pyocyaneus.

At a time when nearly every third case in the hospital suffered from a wound in the discharge of which this bacillus was contained there were certainly ample opportunities for it to permeate the air; if, despite this, a pathogenic microbe was found but once, it is proof enough that the air necessarily contains very few pathogenic microbes. The writer's experience in St. Mark's Hospital, New York, accords with this proposition. The average results of operations in its old building, the very poor accommodations in which premised all the elements of atmospheric infection, were nearly as good as those obtained in the well-equipped new building.

The operating-rooms of Billroth at the old "Allgemeines Krankenhaus" in Vienna were far

from being an anti-infectious ideal. The same remark applies to the greater majority of the prominent European hospitals—for instance, the celebrated Albert Amphitheatre in Vienna, and the clinic of the eminent surgeon Gussenbauer in Prague, as well as the surgical workshops which the writer saw in some Italian hospitals.

Success, fortunately, depends not upon the marble floor of a modern operating-room and upon more or less complicated apparatus, but upon carrying out the principles of asepsis so far as direct contact with wounds is concerned. This fact explains why, under the most unfavorable circumstances, Bassini in Padua was able to perform hundreds of herniotomies in succession without meeting with a single fatal result. At the new St. Mark's Hospital, which really merits the designation of a "model hospital," particularly with reference to modern aseptic appliances, the death-rate is now about the same as it was in the old hospital. This uniformity must certainly be due only to the *rigid observation of aseptic principles in reference to all objects that come into contact with the wound, such as the hands of the surgeon, the instruments, and the field of operation.* One of the gynecologists at the old St. Mark's Hospital two years ago, under very minute aseptic precautions, performed three hundred laparotomies in succession with a mortality of 8

per cent. If, as this rate shows, asepsis depends not upon aseptic operating-rooms, but mainly upon minute precautions in reference to the contact question, there is no reason why success should not be obtained in the poorest abode. The whole matter converges to one point—namely, that operations performed in a tenement-house entail a great deal more trouble to the surgeon, while in a hospital everything can be carried out with the greatest convenience. It is quite natural, therefore, that a surgeon, when he has the choice, prefers operating in a hospital.

If after a laparotomy the patient's abdomen has been closed, his fate is determined, and the condition of the surrounding atmosphere will be a matter of indifference. If the operation was not done aseptically, no kind of after-treatment, nor any secondary opening of the cavum abdominis, will remedy this omission. If danger of infection really threatened from the air, the danger would naturally be greater in hospitals, which shelter many more microbes, than in a dwelling-house.

In *private practice* it would be advisable to select a large room with good light for an *operating-room*. If possible, there should be another room for the occupancy of the patient after operation. Many surgeons recommend the removal of all furniture, paintings, carpet, etc. They even go so far as to wash the walls with

bichloride and to scrub them afterward with crumbs of bread (E. von Esmarch). If these procedures are undertaken a day or two before the operation, nothing can be said against them, but if they are done only a few hours before the operation, they certainly are apt to impregnate the atmosphere with many more microbes, for these procedures whirl up dust, which under such circumstances may become a potent carrier of micro-organisms. Therefore it is by all means preferable to leave the operating-room undisturbed shortly before operating, and to exercise great care that the tables and chairs, and whatever else may be required for operation, are covered with sterilized sheets or towels. If sterilized linens are not obtainable, freshly washed and ironed sheets will do for all covers which do not come into direct contact with the field of operation.

The operating-table, and also the small tables upon which instruments are put, should be constructed of glass and iron, so that they may easily be cleaned with a hot soda-solution or be sterilized in a large steam-apparatus. Chairs upon which instruments, etc. are put should consist of enamelled iron also. Operating-tables should always be made of plain, smooth material, and should not contain any grooves or ornamentation. Their tops should be either of metal or

of plate glass. Numerous tables of this kind, all more or less useful, have been devised, those recommended by Körte (Fig. 44), Sonnenburg, and Edebohls being especially desirable. If such tables are not available, an ordinary strong kitchen table may be utilized, after thoroughly

FIG. 44.—Körte's general operating-table, with foot-lever to set table on casters; iron top, white-enamel finish, slanting to the centre, with a metal gutter for drainage; two detachable drop-plates for operating on the lower limbs; side table for operating on the arm and hand.

scrubbing it with hot soda-solution. An attachment for Trendelenburg's position, such as advised by Cleveland, Boldt, Edebohls, Krug, and others, is desirable.

When economical considerations must guide the surgeon, Leopold's simple and inexpensive attachment may be used. It is a frame (fifty

inches in length and twenty inches in width) constructed with a hinged flap whose lower part—that is, the part upon which the legs rest—can be brought downward, thus forming a right angle with the upper flap, upon which the pelvis and thighs rest. The flap can be raised sufficiently high by a support. This entire frame can easily be fastened to any kind of table by means of iron clamps.

The operating-table should be covered with a folded blanket, a muslin sheet, and a sheet of

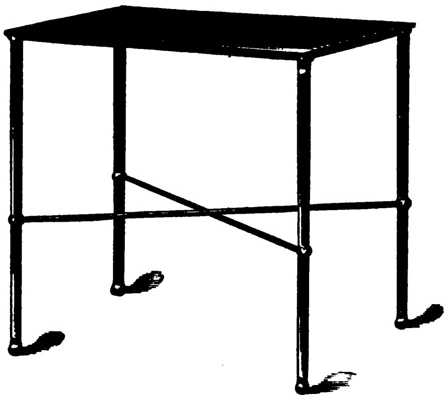


FIG. 45.—Ordinary dressing- and instrument-table, wrought iron, white-enamel finish.

rubber or of oil-cloth. Such sheets may be so pinned together as to form a funnel leading into a pail at the lower part of the table. Kelly's inflatable rubber cushion may be used for this purpose. In its newest form the anterior apron is

doubled into a large funnel for conducting the discharges into the pail.

The instruments used during an operation may be placed upon an ordinary table made of glass and iron (Fig. 45). An instrument-table which is especially useful in hospital practice combines a glass case for aseptic dressings with a lifting-top cover and a hinged side shelf (Fig. 46).

FIG. 46.—Kny's instrument-table.

The instruments of a hospital should be kept in an *instrument-cabinet* composed of iron and glass (as shown in Fig. 47), which may be cleaned easily and thoroughly. The shelves

must consist of plate glass, and should be arranged in such a manner that they may be pulled out separately.

Splints and apparatus like Volkmann's sleigh, etc. should be kept in an adjoining room.

Irrigators are being more and more discarded. Whenever it is possible mechanically to remove

FIG. 47.—Kny's instrument-cabinet with adjustable shelves: a plate-glass partition in the centre practically divides it into two closets.

from a wound coagula, necrotic tissue, granulations, etc. by wiping them from the wound with gauze mops, this method is preferable to irrigation. Irrigation, it is true, removes blood-coagula and secretions and brings bactericidal medica-

ments into contact with the wound, but at the same time it is apt not alone to remove pus and infectious secretions, but also to force such substances into the tissues, so that further infection is favored rather than prevented.

In an infected wound the micro-organisms are sheltered by either the wound-surface, the blood-coagula, the necrotic tissue, or the crusts covering the wound—namely, with material that can never be disinfected by the commonly-used so-called "antiseptic solutions." In large cavities where mechanical cleaning from fibrinous or cheesy masses is indicated—as in pyothorax, for instance—the use of an irrigator is desirable at the time of operation, while later on, when such solid masses are removed, no further mechanical cleaning will be necessary. In plastic operations, especially on the vagina, irrigation is also desirable, as it dispenses with sponging there.

The irrigator should always be made of glass, and the scrupulous cleansing of its rubber tube is of very great importance. A thermometer should be connected with it, so that the temperature can always be ascertained without the unreliable guess of a helping hand. If operations are performed aseptically and as dry as possible, mechanical cleaning with an irrigator is hardly necessary. For an irrigator there may be substituted a graduated glass jar, which can

be sterilized very easily, as it does not require any attachments.

Large pails should always be ready in the operating-room to receive the removed dressings or other waste material, which should never be thrown on the floor. It is desirable to have such pails removed from the operating-room as soon as they have done service.

Each patient, immediately after entering the hospital, should have a *bath*. This bath is an important preliminary operation before local disinfection is begun. Bath-tubs (enamelled ones are best) should therefore be at hand in abundance.

The wards and *the private rooms* in a hospital should, as suggested by the principles enunciated above, be so arranged that they can always easily be cleaned. *Halls* and *floors* should consist of the same material as that used in the operating-rooms. *Beds*, *tables*, and *chairs* should mainly be constructed of iron. *Horse-hair mattresses* and *linen sheets* should be used to the exclusion of all other bed-clothing. If available, two beds should be used for the same patient, as it usually adds greatly to his comfort to move him from one bed into another. Good ventilation is essential. The temperature should be kept uniform. From time to time the wards and the private rooms should be disinfected thoroughly, whether they ever contained an infectious case or not.

Mechanical cleansing, as shown on page 61, is the most important and powerful part of disinfection. After the floor, the walls, and the ceilings, as well as the doors, windows, bedsteads, tables, and other objects, have been scrubbed with hot soda-solution, they should be washed with hot water. The bedding, curtains, etc. must be sterilized either with boiling water or, preferably, with steam. The rooms and their utensils should be aired for several days before use.

IX. ASEPTIC WOUNDS.

Primary union is the ideal toward which the surgeon strives in treating wounds. This ideal can be attained only when strict aseptic precautions have been observed.

Primary union occurs after the walls of a wound have been adjusted accurately and a moderate amount of exudation has taken place, resulting in the formation of fibrin, which temporarily glues together the edges brought into apposition. If the parts have not been adjusted carefully, blood-corpuscles and masses of coagulated fibrin form wherever the walls have not come accurately into contact. Such exudations may organize (moist blood-clot, Section VII., p. 142), but in most cases they impede the healing process just the same as fragments of bruised

and injured tissue may undergo necrosis in consequence of impairment of their blood-supply. To prevent the accumulation of blood in a wound it is essential to stop the bleeding so thoroughly that the wound-surfaces appear absolutely dry before they are united.

To prevent the formation of necrotic tissue all bruised or injured tissue should be removed, to ensure smooth coaptation of the wound-surfaces. When an incision has been made through the superficial tissues, the margins of the wound separate according to the elasticity of the various structures that have been divided by the incision; larger vessels must be caught by forceps and be ligated. Hemorrhage from small vessels soon stops without artificial help, as their lumen will close by contraction of their walls, and the arteries will retract into their sheaths. Total obstruction then follows by the formation of a blood-clot within the vessels. After the vicinity of a wound has been washed with sterilized water and the surface of the wound has been wiped off carefully with gauze mops, the bleeding will cease entirely, and then the edges may be united by sutures. In very large wounds, where more than the usual amount of discharge is naturally anticipated, deep (buried) sutures must be employed to maintain the deeper surfaces in apposition. If this procedure is omitted, the

accumulation of the discharge will separate the opposing surfaces. Sometimes pressure alone may answer for this purpose, and sometimes gauze drainage; and exceptionally a rubber drainage-tube into each corner of the wound will be required to conduct off the wound-product so that the united surfaces may remain adherent.

In the regular course very slight, if any, swelling of the lips of the wound will follow. The tissue in the vicinity of the incision may be somewhat firmer than in its natural condition. This firmness is due to the disturbance in the circulation following the severing of the blood-vessels. There should be no discoloration, especially no hyperæmia, of the wound-surface.

An occluded wound, very naturally, is better guarded against infection than an open wound. But if microbes have invaded a wound during operation, or if there supervene any of the occurrences above described, occlusion may be detrimental to the patient, as blood-clots, as well as necrotic tissue and the wound-products, are the most favorable soil for pathogenic microbes. Whenever there is doubt as to the invasion of microbes, it is better to omit suturing and to follow the principles explained in Section X. concerning Infected Wounds, and those of Section XI., on Open-wound Treatment. When it can be ascertained that, despite strict aseptic pre-

cautions, abundant discharge is to be expected, or when during operation a microscopic examination has revealed the presence of virulent microbes, the introduction of small drainage-tubes, or preferably of lamp-wicks inserted into the edges of the wound or carried through counter-openings, is indicated. *Whenever doubt exists as to the kind of after-treatment, the decision should be in favor of drainage.* The possibility of thoroughly arresting hemorrhage as well as preventing the formation of pockets rests entirely in the hands of the surgeon. Aseptic treatment, however, allows no irritation of wounds, consequently the discharge is generally very scanty.

An excellent *technique* of uniting aseptic wounds, as advised by Neuber, is as follows: After having loosely packed the whole wound with moist sterilized gauze the wound-flaps are united above it by sutures. Small wounds require only a strip of gauze. The edges of the wound are then very carefully adjusted, except at the lowest part of the wound, where it is left sufficiently open to allow the gauze strip to protrude. While an assistant presses a few sponges on the united surfaces the gauze is slowly pulled out from the interior of the wound-surfaces. This gauze is now saturated with blood which has been oozing while the sutures were applied. If it should happen that a few fibres remain when

the gauze is pulled out, these fibres will become encysted in the wound without causing any reaction. Forcible compression by sponges covering the united wound-surface is then used once more, to squeeze from the wound-surface all the blood still contained between the interior wound-surfaces. By drawing together the sutures which have previously been applied the wound is closed entirely, and it is then covered with sterilized gauze.

If the raw surfaces are of an irregular shape, so that a considerable amount of pressure is required to keep them in contact, it is advisable to fasten marine-sponges, enveloped in sterilized gauze, to the wound by gauze bandages.

To secure primary union mastering of the technique of suturing is essential. Of the many methods advised, the following may be mentioned.

Continued Suture.—The most desirable method of suturing is by the continued or glover's stitch, as it can be applied very rapidly. The edges of the wound can also be adjusted very easily when this suture is used. When possible, only straight, spear-shafted needles, of the size ordinarily used by tailors, should be employed. The thread should not be very long, a knot being

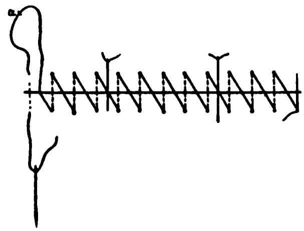


FIG. 48.—Continued suture with relaxation-sutures.

fixed at one of its ends. The needle must be inserted at one end of the wound and about one-third of an inch from its edge, which may be seized by strong mouse-toothed forceps. The first suture may be applied as an interrupted suture, but without cutting the threads after the knot is tied, or the procedure may be carried out in the same manner as the ordinary tailor-stitch is made.

The needle is first carried through one lip of the wound and then through the other, where a loop is formed, through which the end of the thread is drawn so that it can be fixed in a knot. If desirable, a small gap about one-third of an inch in length may be left for drainage. If the wound is very long, the continuous suture may be interrupted by making loops at intervals of three or four inches. In long wounds, or where-ever any considerable amount of tension exists, it is advisable to apply *relaxation-sutures* at intervals of one and a half inches in addition to the continued suture (Fig. 48). For such sutures the needle should be introduced three-fourths of an inch from the edge of the wound. While it is convenient to use catgut for continuous sutures, provided it is not applied in cavities like the peritoneum (see p. 132), the relaxation-suture should always be of strong silk. The continuous suture is especially valuable in those cases where suc-

cess greatly depends upon rapidity, as in operations on the peritoneum and the intestines.

The *interrupted* suture (Fig. 49) is the one most commonly used. It can be applied with either straight or curved needles. Catgut or silk may be used, according to the principles of Section VI. One edge of the wound is seized with mouse-tooth forceps and is perforated with the needle; then the same manœuvre is repeated on the opposite side. If there is little tension, an assistant may so approximate the wound-edges that with one stitch both edges may be transfixed at the same time. The knot of the suture should always be applied laterally from the wound. Sutures should not be applied too tightly, as tension may produce irritation, necrosis, and abscesses in the stitch-holes. If there be any tension, however, it is advisable to intertwist the ends of the thread twice, making a surgical knot.

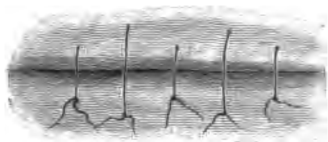


FIG. 49.—Interrupted suture.

The suturing should always begin at the middle of the wound, and not at its ends, especially in long wounds, as the edges may be adjusted much more easily if done in the former way. As a rule, about three stitches to the inch should be used. The needle should be introduced about a

quarter of an inch from the edge of the wound. If relaxation-sutures be required, they must be applied first; in making them the needle should be introduced at least half an inch from the edges of the wound. In long wounds relaxation-sutures may serve as *situation-sutures*—that is, they may answer the purpose of landmarks. Perfect approximation is always of the greatest importance.

If even a minute portion of the edge of a wound be turned inward because of imperfect edge-adjustment, necrosis of this small area may occur and may be the indirect cause of further pathogenic processes which, under unfortunate circumstances, may lead even to the death of the patient. (Compare Section XII., p. 230.)

The *silver-wire* suture is very valuable in suturing bone-fragments, and sometimes for relaxation-sutures. The writer found it very useful in operations on the tongue and the lips, as a prophylactic suture.[1] In operations upon the lips it is of particular importance to reduce the amount of hemorrhage to a minimum, because those concerned in these operations, which are generally done either for hare-lip or for epithelioma, are babies or aged individuals—that is, delicate and feeble patients, in whom even a moderate amount of hemorrhage may be fol-

[1] "Ueber Hasenscharten-Operationen," *New Yorker medicinische Presse*, March, 1888.

lowed by deleterious consequences. Based upon this experience, the writer has advised in such cases a prophylactic suture, the idea being to apply a suture *before* any cutting has been done (Fig. 50). The technique is the following: Having planned the lines of incision, the integument is pricked with a sharp knife as a guide for the subsequent incisions. An Emmet blunt needle (a sharp needle might cause excessive bleeding) armed with a wire is then introduced, and hangs down like a sling, so that it cannot interfere with the incision. Then an assistant seizes the flap with his thumb and index finger, the flap is cut out as indicated by the preliminary incision, the edges are pulled together quickly, and the wire is twisted, thus checking the hemorrhage immediately. After this it is very easy to do whatever trimming is necessary. In case an exact approximation has not been obtained, another wire suture may be applied in a better position, the first one being taken out. The prophylactic suture may then serve as a relaxation-suture (Fig. 51). If another incision should be required, it is easily done, and the bleeding can occur only during the time of making the incision. The main advantage of silver wire is that it can easily be made sterile by simple boiling. On other suture material compare Section VI.

In deep wounds *subcutaneous* or *buried sutures*

are often necessary. In making buried sutures each layer beneath the integument must be sewn separately, so that the surfaces of the wound, as well as the skin, can be adjusted properly. Thus pockets are avoided, and divided structures, such as tendons, nerves, muscles, aponeuroses, and fasciæ, may be united. It should always be borne in mind that exact suturing is an integral part of aseptic treatment. After

FIG. 50.—Beck's prophylactic suture.

FIG. 51.—Prophylactic suture as relaxation-suture.

suturing, the whole area should be covered with a layer of aseptic gauze, then with cotton or moss.

Immobilization is naturally of great importance. Where moss-board (Fig. 34) is not strong enough to answer this purpose, splints consisting of wire or of plaster of Paris must be employed. After such operations as laparotomies, wherein splints for immobilization naturally cannot be used, they must be imitated by administering morphine to arrest peristalsis, etc. Immobiliza-

tion can sometimes be carried out by surrounding the dressing of large wounds with a plaster-of-Paris bandage. If the patient is restless, such bandages should be used around the abdomen and both legs, especially after operations such as those for inguinal or femoral hernia.

If all the above rules are carefully observed, hardly any disturbances, under ordinary circumstances, will be noticed. The dressing may, as a rule, remain unchanged until recovery. The patient's pain, if any follows the operation, usually ceases on the subsequent day, and the most that is complained of is a slight sensation of discomfort. As soon as the nausea and headache following anæsthesia have passed off, the patient should regain his appetite and be able to sleep, and he should feel as in his normal state. A contented expression of a patient on the day following laparotomy generally presages a favorable course for the case.

Aseptic wounds treated as described above heal more rapidly than those which are united without using pressure or those in which drainage has been employed. Another advantage of the aseptic method is, that if wounds heal under one simple dressing, there can be no danger of secondary infection by changing the dressing. And even when infection has possibly been avoided in renewing the dressings the wound

will be irritated greatly—a fact which manifests itself generally by a slight elevation of temperature shortly afterward. While under the old antiseptic treatment about two-thirds of the cases showed an elevation of temperature, this phenomenon is observed only in one-third of the cases treated aseptically as described above.

The characteristic features of this so-called *aseptic fever* are as follows: It generally sets in immediately after the operation has been performed, while *septic fever* usually does not begin before the day following the operation; the temperature in aseptic fever ordinarily does not exceed 102½° F., but may exceptionally rise even to 104° F., precisely as in septic fever, but, by constantly decreasing, aseptic fever ceases in two or three days; furthermore, in aseptic fever the pulse is regular and strong and rarely exceeds 110.

Aseptic fever is due to the absorption of fibrin ferment, a substance which can be obtained artificially from defibrinated blood. If this ferment is injected into animals, it causes coagulation of the blood, and generally death. Fibrin ferment is produced by the breaking down of minute portions of the wounded tissues, especially of blood-coagula. This explains why the fever caused by the ferment sets in immediately after operation, while in an infected wound the pathogenous microbes which invaded the wound develop and

multiply comparatively slowly, thereby producing the ptomaïnes whose absorption causes septic fever. It must be assumed that one or a few microbes do not necessarily cause any symptoms of infection, as the vitality of the tissues may be able to destroy such a small number, but that the symptoms become perceptible as soon as the microbes are produced in quantities and toxines form accordingly.

During the twenty-four hours following an operation a distinct prognosis as to the course of the wound cannot, as a rule, be given, but after this time, if symptoms of infection remain absent, it can be assumed that no disturbance will follow. It is only in exceptional cases that symptoms of infection develop later. Such late infections are supposed to be due to poor observance of aseptic precautions while removing the dressings.

X. INFECTED WOUNDS.

While it should nearly always be possible to prevent infection of a wound made by the surgeon, it is practically impossible thoroughly to disinfect a wound, in the common sense of the word, after infection has occurred. It is quite easy to sterilize an instrument or a towel in boiling water or in steam, but it is impossible to use

such strong disinfecting agents on human tissue; nor can antiseptic solutions, even if they could be borne in full strength, directly permeate tissues which have been invaded by microbes. Wound-products containing a considerable amount of albumen combine with the antiseptic solution, thus weakening or even annulling its influence. Furthermore, as demonstrated in Section III., considerable harm may be done the tissues by using strong antiseptics, as the microbes can much better withstand antiseptic drugs than can the tissues. If even only so weak a solution as one of 3 per cent. of carbolic acid be used on a wound, its surface loses its red color and turns gray, evincing superficial necrosis of the tissues. With reference to the toxic influence of strong antiseptics, it must be borne in mind also that an infected patient, who is consequently more or less debilitated, is thus less able to resist poisonous drugs than is a non-infected one.

As before stated, surgeons are not yet in possession of drugs able to disinfect infected wounds in the true sense of the word; hence, being unable to kill the enemy directly, there must be employed combined measures of attack. If the enemy cannot be combated successfully by storm, he must be starved out. The first thing to be done is to cut off supplies—in other words, to destroy the soil that nourishes the microbes,

or to employ such means as are apt to prevent their development and multiplication. If infection of wounds has taken place, it is important to recognize this infection as soon as possible, so that further spreading of the infectious elements may be checked and general infection be prevented.

Clinically, infection is manifested by the various forms of inflammation and suppuration. They may consist of a common superficial suppuration limited to the wound, or of an inflammatory process surrounding it, and they are commonly called "cellulitis" or "phlegmon" (from φλεγμονή, inflammation). Cellulitis may lead to a circumscribed suppurative process called "abscess," or to diffuse, often rapidly progressing, inflammatory and suppurative processes. The worst form of this progressive inflammation and suppuration is the septic phlegmon, which is a diffuse purulent cellulitis.

The propagating inflammation of the skin and the subcellular tissue called "erysipelas," which only a few years ago was still very frequently observed, consists in an inflammation of the lymphatic vessels and is caused by the streptococcus erysipelatis (see p. 38).

The most fatal poisoning of the whole system following infection of a wound is sepsis (septicæmia, septæmia). A very similar intoxication produces the symptoms of pyæmia (pyohæmia—

πύον, pus, and αἷμα, blood), whose characteristic difference from sepsis consists in the formation of metastatic abscesses in various organs of the body. This metastatic suppuration is accompanied by the intermittent type of fever in pyæmia. A distinct differentiation, however, cannot be made between sepsis and pyæmia, as both conditions may often be combined, and they may frequently produce the same pathological and anatomical as well as clinical symptoms. The question arises whether all such infections should be treated on the same principles. As demonstrated in Sections I. and III., there may be present in infected wounds, besides the ordinary pus microbes, other micro-organisms whose characteristics are yet unknown.

There must necessarily be a difference between a simple abscess containing so-called *pus bonum ac laudabile* (if this antiquated term may be allowed) and a putrid decomposition. The different conditions therein certainly require somewhat different treatment.

With a view to arriving at a guide, inoculations were made of a series of isolated and cultivated pathogenic microbes from putrid fluids. The inoculations always resulted in a reproduction of the same kind of septicæmia. It must be borne in mind, however, that such microbes, despite their being taken from putrid liquids, need not neces-

sarily produce putrefaction, nor can they be transferred to every species of animal. There are certain species of animals which possess well-marked immunity to certain microbes, and there are other species which always show a decided reaction after being inoculated with specific kinds of microbes. This shows that there are various forms of animal septicæmia. For instance, the bacillus of sepsis in mice (Pl. III., Figs. 5 and 6) produces no symptoms in rabbits (Section I., p. 21). Furthermore, it shows that sepsis in human beings is not identical with the sepsis of certain animals. The microbes which cause wound-inflammation in cows, horses, and other animals differ entirely, according to the observation of veterinary surgeons, from those which cause inflammation in human beings, and seem to vary in their peculiarities according to the various species of animals, so that these experiments can be utilized for human beings only in a restricted way. It is true that staphylococci and streptococci taken from cellulitic processes in human beings can be transferred to guinea-pigs, mice, and rabbits, and cause the same pathological changes in these animals; but most other microbes cause either entirely different reactions or none at all; so that by these interesting experiments it could not, in fact, be proved whether the series of clinical symptoms comprised under the

denomination "sepsis" are or are not due to one single agent. (Compare Section I., p. 51.)

It may be that various forms of sepsis exist, whose differentiation cannot yet be made because of the still defective means of diagnosis. Some microbes can be recognized by the microscope (see p. 88), and thus a determination as to the particular means of disinfection to be selected is easily made. The great majority of microbes at present known, however, can be made out only by bacteriological examination; this has the disadvantage that the cultivation of most species consumes such a long time as often to be practically useless. It is superfluous to urge the importance of such examinations in reference to prognosis.

Pasteur has shown, however, as explained in Section I. (p. 27), that one must distinguish between aërobic and anaërobic bacteria, the first developing best in oxygen, the latter being unable to exist in it. In wound-cavities or in effusions following inflammatory processes, as well as in suppurative processes—as those in the gall-bladder, for instance—no oxygen can be discovered; therefore those microbes which produce these conditions must be anaërobic—that is, they must be able to develop and to multiply without oxygen. *If such is really the case, then the microbes would necessarily die as soon as exposed to the atmosphere.*

Long before it was known that anaërobic microbes are destroyed by exposure to oxygen, surgeons, guided by nothing save practical experience, knew that if free access of air to a cavity was procured—that is, if a broad opening was made—further injury to the infected tissues could often be prevented. In fact, while the brilliancy of that part of modern surgery which is mainly based upon prophylaxis has passed far beyond the surgery of the past, the results in the treatment of infected wounds leave much to be desired.

Long before antisepsis and asepsis were dreamed of, it was emphasized that free access must be furnished infected wounds by incision and drainage. Surgeons are unable to do much more to-day. It may safely be maintained that the greatest step in this small progress in methods of treating infected wounds dates only from the first methodical packing with iodoform gauze. Brush and sterilizer alone, valuable as they are, do not complete the *armamentarium chirurgicum* in this battle against conditions practically inestimable in their consequences. At this point some other factors of surgical technique must be taken into consideration. A. Jacobi, in his admirable address[1] delivered before the Eleventh International Medical Congress, asks: "Is it enough

[1] "Non Nocere," *Medical Record*, May 19, 1894.

to know that clean finger-nails, and nurses conversant with corrosive sublimate, and disinfected catgut, are almost universal safeguards against immediate fatal termination?" Certainly not; there is requisite a series of procedures the mastering of which presupposes a perfect knowledge of a whole science; and even this is very defective.

If, notwithstanding all aseptic precautions before operation, through omission of such safeguards as alluded to, through oversight, or through any unfortunate accident, infection has taken place, an early recognition of the symptoms is of the greatest importance, so that the necessary steps may be taken to arrest the process before it spreads and general infection occurs.

The *symptoms of infection* are both general and local. In the great majority of cases infection can be recognized by the manifestation of general symptoms, the most important of which is fever. As shown in the preceding section (p. 170), the main difference between infectious and aseptic fever is, on the one hand, that the symptoms of the latter fever begin immediately after operation; furthermore, that the temperature generally does not exceed 102½° F., and soon returns to normal; on the other hand, it is characteristic of infectious fever that it does not begin before twenty-four hours after the operation, and that at its

onset the temperature rises to 104° F. or even higher. The symptoms of infectious fever generally start with a chill, but the pulse usually indicates infection before the other symptoms become manifest. A pulse-rate of 120 or more per minute is a very suspicious symptom, and, whether associated with a low or a high temperature, announces a serious condition.

In the further course of the most deleterious septic processes a normal temperature is often found. This normal condition may more readily deceive the inexperienced surgeon as patients affected with this particular form of sepsis generally feel well notwithstanding the hopelessness of their condition. In septic conditions, at their onset a superficial observer may overlook the rise of temperature, and as a few hours later the temperature may have fallen, the rise may have escaped notice entirely. If the patient reports no real chill, but only slight shivering, such as sometimes occurs at the beginning of septic fever, this error is much more easily made.

At the beginning of the fever the general condition of the patient is usually also impaired, weakness, anxiety, and sleeplessness predominating. Profuse perspiration is very often present. The tongue may be clean, but it is always dry. It is perhaps superfluous to state that these symptoms imperatively demand immediate inspection

of the wound. Even if only one of these symptoms be present, the dressing should be changed; in case of doubt it is preferable to make this change unnecessarily rather than to risk the consequences of its omission.

In accordance with the general symptoms, the *edges of the wound* usually appear inflamed and the skin is reddened and tender. At an early stage of the fever pain is seldom absent. The degree of infection and the extension of the local inflammatory process differ materially. They fluctuate between slight lymphangitis and fatal acute purulent œdema. A surgeon may incur a slight infection of the index finger while operating upon a putrid abscess. A small cut or a superficial and unnoticed abrasion of the skin on his finger may represent the avenue of entrance of the infection. A chill may follow twenty-four hours later, and his temperature may rise to 104° F. The small sore on his finger may become inflamed and may be the seat of throbbing pain. The cubital as well as the axillary glands may swell, and on the skin of the arm red stripes, the evidence of lymphangitis, may appear. The following day the whole infectious process may have terminated, or it may be that the process was localized or limited by the production of circumscribed abscesses either at the initial lesion or in the glands. It may also happen that general in-

fection takes place, the process ending only with the death of the surgeon.

It would exceed the boundaries of this volume to enter into further details of the pathological significance of these various infectious processes, but observation teaches that at present diagnostic means are not sufficiently advanced to enable one always with certainty at an early stage to distinguish between an innocent and a fatal character of infection, except under the conditions alluded to on page 88. Therefore, in brief, all kinds of infectious symptoms must be deemed serious. Even the most innocent-looking suppuration of a stitch-canal may, through the accumulation of unfortunate circumstances, be the beginning of a grave course.

Suppuration of stitch-canals develops from the canals of the sutures, and is generally caused by catgut or silk which either was not thoroughly sterilized or which became infected during operation. The danger of suppuration will be enhanced by the presence of considerable tension where there is a tendency of the wound-edges to gape. Suppuration of stitch-canals may be superficial as well as deep-seated; the latter especially may be expected in buried sutures. When suppuration is only superficial, the symptoms, naturally, are not so intense as when it is deep-seated, for the first condition is readily followed

by early and spontaneous discharge of pus through the integument. As a consequence the general condition of the patient may be disturbed so little that suppuration is not noticed before the dressing is changed, when attention will be called to it by the escape of a drop of pus from a stitch-canal.

Pus very often appears only after the suture has been removed. In case of *pus-retention* there will be observed redness, infiltration of the wound and the adjacent parts, and pain on pressure. It is evident that sutures must be removed without delay when their canals suppurate; this removal alone sometimes suffices to prevent further suppuration. If retention is discovered, incisions should be made to liberate the pus.

Sometimes *blisters* filled with a sero-purulent fluid are present. In this case the epidermis must be removed. This is done best with scissors curved on the flat.

If suppuration follows the application of *buried sutures*, local as well as general symptoms are of much greater intensity. In the majority of cases the patient shows a high temperature (at least 103° F.), the pain becomes intolerable, and the patient complains of a pulsating sensation in the wound. There are also present headache, loss of appetite, and other general symptoms.

In such cases after the dressing is removed there will be noticed intense redness and a painful infiltration of the tissues. Collateral œdema will seldom be absent. A fluctuating point may now be discerned, or a part of the pus may be discharging through one or another of the stitch-canals.

If an abscess has formed between two *stitch-canals*, it generally suffices to introduce a Péan forceps through the line of incision and to separate the edges of the wound by opening the blades of the forceps. If the pus cannot be evacuated in this way, incisions are in order; they should be made rather too long than too short, so as to relieve tension while permitting the discharge of the pus.

If *superficial gangrene* of the lips of the wound occurs, their immediate removal with forceps and scissors is indicated, for gangrene will present a most favorable soil for the development of microbes, at the same time causing retention of pus. Whenever symptoms of infiltration and swelling are found, even before any evidence is presented of the presence of pus, an incision should be made. (See Section XII., on Renewal of Dressings, p. 230.) By making incisions thus early it is often possible to prevent necrosis in fasciæ, in the sheaths of tendons, or in bones.

In *extensive phlegmonous processes* a very

thorough examination of the adjoining and apparently healthy parts must be made, as they sometimes retain pus. The graver the general symptoms, the more extensive should be the incisions. The incisions should expose the area of the suppurating process as extensively as possible, and all edges and pockets should be laid open. In deep-seated phlegmons an incision through the skin and fascia must first be made, and a passage be established with a grooved director or a small Péan forceps. If the focus is found, the passage may be dilated with the forceps. The next procedure is to *keep the abscess-cavity open* by drainage, which can best be accomplished by employing absorbent gauze. Rubber tubes will only exceptionally be required.

These procedures, especially the evacuation of pus and the thorough removal of mortifying tissue, are apt to destroy the soil which favors the development and multiplication of microbes, and they are therefore of far greater importance than the use of any or all of the so-called "antiseptic solutions." In fact, these procedures deserve much more the name of *disinfectants.*

Schimmelbusch[1] claimed that no infected wound can be disinfected even though an antiseptic fluid be applied immediately after infection. Not only

[1] *Transactions of the XXII. and XXIII. Surgical Congresses*, Berlin, April 15, 1893, and April 18, 1894.

bichloride, carbolic acid, lysol, acetate of aluminum, chloride of zinc, etc., but also caustics like nitric and acetic acid, were used without the slightest effect. This result shows that the micro-organisms permeate the tissues very rapidly, and as speedily get beyond the reach of antiseptic liquids. Five minutes after the introduction of pathogenic as well as non-pathogenic microbes into fresh wounds, the internal viscera contained them. Fortunately, as especially shown in Section III., these conditions do not correspond entirely with those represented in surgical practice, as the patients ordinarily are not inoculated with pure cultures of highly virulent micro-organisms. Clinical experience has shown that much can be done in infected wounds by following the principles of open-wound treatment (see Section XI.).

Henle[1] claims that he was able to disinfect wounds inflicted upon rabbits' ears by streptococci with solutions of bichloride (1 : 1000) and of carbolic acid (4 : 100) two hours after inoculation; six hours afterward he was unable to do so, but the severity of the infection was considerably diminished.

[1] *Deutsche Gesellschaft für Chirurgie, XXIII. Congress*, Berlin, April, 1894.

XI. ASEPTIC OPEN-WOUND TREATMENT.

As shown in the preceding section, infected or suppurating wounds should, as a rule, be kept open. The same plan should be followed in all wounds other than those inflicted by the surgeon, as such wounds must practically be regarded as contaminated.

A commonly-adopted surgical principle demands coaptation of divided surfaces by sutures. Whenever it can be determined that no contamination of the wound has taken place, such coaptation will be wise; but this can never be proved in accidental injuries, hence there is always a risk in uniting such wounds. Were one really able to do what all text-books advise and what most regard as an undeniable possibility—namely, the thorough disinfection of a contaminated wound by simply washing it with so-called disinfectants—the omission of the suture would be inexcusable. *But the only fresh wounds that are really aseptic, in the true sense of the word, are those made in healthy tissues by aseptic instruments in the aseptic hands of a surgeon.*

An accidental wound perchance may be aseptic, but it necessarily must have been inflicted on a clean person by a clean instrument, and little time must have elapsed before it came under the observation of the surgeon. The chances may

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OPEN-WOUND TREATMENT.—1. Aseptic hip-joint resection: sawing off head of femur; 2. Wound partly united and packed with gauze ready for application of moss-board.

then be that if the principles detailed in Section IX. on Aseptic Wounds, are observed, union by first intention may be obtained. Hence compound fractures with small wounds of the integument—gunshot wounds, for instance—show a great tendency to heal if they are treated aseptically—that is, if they are merely cleansed according to the principles of prophylactic disinfection described in Section IV.

A priori, it may be assumed that a bullet carries with it pathogenic microbes from the clothing, etc.; but clinical experience shows that infection very rarely occurs in this way, provided the surgeon avoids severe manipulations, such as probing, incising, draining, etc., and simply follows the principles of prophylactic disinfection. It may be that to some extent the heat of the bullet has something to do with the frequent aseptic course of gunshot wounds.

During the Franco-German war (1870) Bernhard von Langenbeck had the opportunity of observing at one time eleven cases of gunshot wounds in the knee-joint. According to the routine of that time, all patients were told that if they would not submit to amputation they must die. Ten consented to amputation, and died with the satisfaction of having been treated *secundum artem;* but one patient, a stupid soldier who preferred death to amputation, recovered.

Nowadays the real scientific question to be determined is whether or not any microbes can be discovered and cultivated, and if so, what species. The absence of microbes or the presence of innocent ones would require coaptation of the wound-edges, while the presence of virulent microbes would demand open-wound treatment. But this conclusion can be arrived at practically only under the conditions described in Section III., on the Means of Disinfection (see p. 88), and so the experience and ability of the surgeon must frequently govern the decision as to whether a solution of continuity shall be treated as an open or as a closed wound. A wound inflicted by a stone upon a labor-soiled hand has poor chances of union by first intention, therefore to seek to obtain such union would be useless.

The principles governing the open treatment of wounds were followed long before the terms *antisepsis* and *asepsis* existed. It was well known that an irregular wound converted into a smooth-surface wound in which neither retention, decomposition, nor absorption of the wound-products is possible offers better chances for healing if treated by the open method than if it were occluded.

In 1806, Vincenz von Kern, an eminent German surgeon, recommended the open treatment of wounds (*pansement à ciel ouvert*) as a method.

He saw that it was likely to prevent putrefaction by keeping the edges of the wound well separated, thus giving free access of air and at the same time permitting escape of the discharges. His results were the most favorable known at that time. His method was employed especially after amputations, when, hemorrhage being thoroughly stopped, the entirely uncovered stump was laid upon a pillow so that the discharges could flow into a basin placed beneath. Healing took place by suppuration and granulation. The discharges always freely escaped, and consequently purulent absorption could not take place. In large and complicated cavities this method, unfortunately, was not so rigorously carried out, probably because of the fear which prevailed in former years of making large incisions.

An *irregular cavity*—that is, a cavity in which several wound-canals lead toward various parts of the tissues and end in small cavities that present superficial openings—would, if left uncovered, not answer the spirit of this method. True, the air would be able to enter, but it would not have access to all portions, nor could it circulate in the cavity. Superficial or temporary union of these deep-seated cavities might even entirely occlude them from the atmosphere. They would then become veritable hot-beds for the development of micro-organisms in the retained dis-

charges. Such cavities must be exposed as freely as possible, the pus must be allowed to escape, and the broken-down tissues must be removed. The question then arises as to the best manner of keeping open the exposed parts. Von Mosetig-Moorhof devised a method which not only answers this purpose, but which at the same time also exerts a decided and permanent microbicidal influence upon the infected tissues. This method consists in methodical draining or in tamponing with iodoform gauze, the preparation of which has been described on page 123. As shown in Section III. (p. 83), iodoform is not an antiseptic in the same sense as carbolic acid or bichloride. But undoubtedly iodoform renders the products of the microbes in question harmless by forming with them innocuous combinations. In organic tissue a decomposition of the iodoform takes place, nascent iodine probably being set free, during which process bactericidal effects are exerted.

It is essential, after the preliminary conditions described above are fulfilled, that the gauze be brought into contact with every portion of the wound, as iodoform has no effect save by immediate contact. The packing should be done as loosely as possible, except when pressure is required to control hemorrhage.

If rubber drainage is used, no antiseptic

influence will be exercised upon the wound or the cavity itself; but when in a united wound the antiseptic gauze covers the outer ends of the tubes, it prevents decomposition of the wound-products only after they have left the tubes and have entered the gauze, so that the absorbent qualities of the gauze, which are of great value, are not utilized. If a cavity be packed thoroughly with gauze, every particle of discharge must be absorbed, and, however large the cavity, *the pus will be in the gauze only*, and the wound-surface cannot be otherwise than dry.

A drainage-tube does not withdraw or absorb pus, for it has no power to aspirate the pus, which merely traverses the tube, its lumen being the point of least resistance. But the flow through the tube occurs only when pus is abundant, which is the first step to its retention.

If the cavity be left open, the surgeon will be able to examine the field of operation, which examination will be impossible when the wound is occluded. Large incisions enable the surgeon to inspect as much of the tissue as possible, and it is almost as desirable to inspect suspicious wound-surfaces after operation as it is to do so during operation. Oftentimes tissues which at the time of operation were supposed to be of sufficient vitality, become later on gangrenous; or in operations on tubercular joints or glands

tubercular tissue has been overlooked and left *in situ*. It is little trouble to remove such diseased portions from an open wound later on, while if coaptation was the aim of the surgeon this valuable feature would be relinquished.

Amputation of a finger may illustrate the principles underlying open-wound treatment. Let it be assumed that a phalanx of a machinist's finger is crushed by a machine. The appearance of the finger in this case will show considerable change, and the edges of the wound will be irregular. Bloody infiltration, blue or black discoloration, swelling, and irregular form of the finger are striking characteristics of the degree of destruction. As the amount of infiltration of the tissues varies according to the amount of the force to which they have been subjected, extravasation may extend far beyond the wound. The edges of the wound as well as the deep-seated tissues may be so crushed that perfect necrosis has taken place. Bleeding may be stopped by the crushing, and sensation in the part may be lost entirely. Fasciæ, tendons, and nerves may be crushed, and the phalanx may be reduced to a number of fragments. In this case conservative surgery is at a loss. The phalanx must be removed, not only because it is useless to the patient, but because it would also be an incubator for the development of microbes, proving

of great danger for the hand, the arm, or even the life of the injured man, as a wound of this kind cannot but be regarded as infected.

After the necessary aseptic precautions (see Section X., on Infected Wounds) have been taken, the fingers and the hand are scrubbed thoroughly with a brush and soap. These procedures follow the use of ether for removing any fatty and oily substances with which the clothing of the patient or the inflicting instrument—for instance, the wheels of a machine—may have been contaminated. Then alcohol and the bichloride are used, after the principles of prophylactic disinfection (Section IV., p. 95). The whole arm must then be enveloped, and the entire vicinity of the injury be covered, with sterilized towels taken directly from a sterilizing apparatus. The necessary instruments—namely, knives, retractors, bone-cutting forceps, strong forceps to hold bone-fragments, tenacula and artery forceps, and dressing material—must be sterilized in the manner described in Section V. If, as may happen in private practice, a sterilizer is not available, the instruments, etc. may be made sterile in a common boiling-pot (see Section XVI.; Fig. 63).

If the tissues on both sides of the finger are fit for use, a double flap may be formed. The aggregate length of these flaps, which may consist of skin only, must be somewhat more than

the diameter of the finger at the level at which the bone is exsected or disarticulated, and only when amputation higher up is necessary is it advisable to leave some healthy muscular tissue in connection with the skin-flap.

Such procedures are very much facilitated by the *Esmarch method of constriction*—that is, by firmly applying a rubber bandage from below upward, without reverses, to just above the wrist. The rubber band is carried around the limb and is well stretched. After it is tied by its crossed ends or secured by its hook and chain, the rubber bandage which was carried around the limb may be released.[1] After removing all tissues whose vitality seems impaired, and after bleeding is carefully arrested, the flaps are kept widely separated by iodoform gauze which is brought into close contact with each angle or pocket of the wound. A piece of sterilized moss or a voluminous mass of steril-

[1] Previous to employing an Esmarch bandage the limb should be enveloped with a sterilized towel or a bandage, which may be cut or lifted from the site of operation after the constricting bandage is taken off. It being somewhat difficult to keep rubber bandages sterile without impairing their usefulness, Neuber, Bardeleben, and other surgeons returned to the old method of Stromeyer, who used only strong linen bandages moistened before application. There can be no doubt that the marked ease with which linen bandages can be made and kept sterile, as well as their durability, is a great advantage. Their application, furthermore, is followed by far less parenchymatous hemorrhage, after the constriction is released, than occurs after the use of the rubber bandage. Their main disadvantage is the greater care with which they must be applied.

ized gauze must then be applied over the stump to absorb the sanguineo-serous discharge of the wound-surfaces.

A splint of some kind should always be employed. A long piece of moss-board merely dipped into, and not soaked in, sterilized water answers the purpose admirably, for if the discharges become abundant they will readily be absorbed by the moss splint without impairing its value as an immobilizing apparatus. The dressing should reach to the elbow.

If the patient's condition remains normal and if no local symptoms supervene within forty-eight hours, the wound may be deemed in an aseptic state. The dressing must then be changed and the packing be withdrawn. If the surfaces appear clean and healthy, the flaps may be approximated accurately and be kept adjusted by carrying long strips of iodoform gauze around them. If coaptation is thus not sufficiently thorough to make the surfaces adhere, the discharges may continue and imperfect union may result. But even in such a case retention can hardly take place, as the amount of pressure exerted by the surrounding gauze is so slight that the discharge easily finds its way out into the gauze. If there should, however, be any fear of retention, a small strip of gauze may be inserted into one angle of the wound.

In the great majority of cases union by first intention is still obtained in this way, and it should certainly be striven for if, on the change of the first dressing, an examination of the wound-surfaces shows healthy granulations. It is generally unnecessary to apply secondary sutures in such cases. In wounds occluded immediately after operation, when they have become infected or distended by blood-clots reopening is imperative (see Section XII., on Renewal of Dressings); primary union, on the contrary, may still be secured, even if sutures are applied so late as three days after operation, provided the wound is then in an aseptic state.

A patient suffering from an injury such as described might have recovered a few days earlier if sutures had been applied to his finger at the time of the operation; but it cannot be denied that the risk of further infection is considerably lessened by the above-described open-wound treatment. The delay is decidedly preferable to the risk of infection on account of too thorough occlusion. The absorption of septic material will then not be arrested by reopening the wound, nor will a fatal course be stayed.

Where cosmetic points come into question—in wounds upon the face, for instance—the principles of first and of secondary union may sometimes be combined. The wound may be united

partially, especially where the edges are easily approximated, and at different points between the stitches iodoform wicks may be introduced and be allowed to remain for two or three days, or until there is no doubt as to the aseptic state of the wound.

If the wound-surfaces do not show *healthy granulations*—that is, if there are symptoms of infection—and if at the same time the general condition of the patient is impaired, the packing must be continued. The views on obligate and facultative anaërobes discussed in Section I. now find their practical application in our allowing free access of air—that is, of oxygen—to the wound.

Knowledge of the biological peculiarities of pathogenic bacteria facilitates their destruction, or at all events aids in the prevention of their further multiplication. The more dangerous is the quality of the infectious element—that is, the more grave is putrefaction—the more strictly do the laws of anaërobiosis apply. The access of oxygen alone can do much more to destroy bacteria than can oceans of bichloride.

In putrid wounds no efforts at drying discharges should be made. The absorption of the discharges would be a grave error, inasmuch as they originate from a decomposed septic focus, and undoubtedly would become stagnant beneath

the dry dressing. In this position the discharges would prove merely a protection for the microbes, which would then be surrounded by their products, the toxines. These toxines would form a kind of bulwark for the microbes, thus rendering them so much more resistant to disinfecting procedures.

Free access of air is best obtained by extensive incisions (even if they are only of an exploratory character) into suspicious tissue and by radical and repeated excision of apparently necrotic portions. In such cases it is justifiable even to remove tissue not completely necrosed; but when the appearance of the tissues (especially their discoloration, loss of firmness, etc.) manifests considerable impairment of vitality—as, for instance, in burns of the third degree—they must be removed without delay. *Loose packing* with gauze (preferably iodoform gauze), especially if the gauze is not fastened by a roller bandage, but remains in the wound-cavity uncompressed, does not interfere with circulation of the air in the exposed interstices.

As clinical experience shows, moisture, while it should ordinarily be avoided in the treatment of wounds, is well borne in *putrid wound-cavities.* Moisture can be applied by soaking the gauze introduced into the cavities with a weak solution of bichloride every hour; a 1 : 5000 solution

generally proves strong enough for this purpose. If packing has been done, however, antiseptics must be applied to a cavity in a liquid form, to enable them, by permeating the gauze, to come into direct contact with the wound-surfaces and to exercise a permanent influence upon them. Sterile gauze can be used for this purpose as well as iodoform gauze, the latter being preferred by the writer, as the influence of iodoform is not impaired by its contact with the bichloride solution. While in aseptic wounds the dressing should be left undisturbed as long as possible, in infected wounds its renewal even two or three times a day would not be excessive.

In surfaces of great extent, as in burns of the second and third degrees, weak antiseptics (salicylic or boric acid or acetate of aluminum) may be used. The least poisonous of these drugs is the acetate of aluminum: 1 to 2 per cent. of the drug in boiled water generally answers the purpose (see p. 81). These drugs are partially absorbed by the skin, and, although they cannot really disinfect an infected wound directly, yet in the course of time they exercise an indirect influence by diminishing the multiplication of the microbes. If bichloride be preferred, a strength of 1 : 1000 (later on, when healthy granulations appear, 1 : 2000 or 1 : 5000) will serve this purpose; but such disinfecting influence is possible only when the main

requirements—namely, free incisions and free access of air—are fulfilled.

Immobilization is a strong adjunct in the treatment of all kinds of wounds. Therefore, if, as alluded to in the case of the infected finger, the primary focus as well as its suspicious vicinity be exposed freely and loose packing be done, a splint reaching as far as the elbow should be adjusted, preferably at the side on which no incisions have been made. The most desirable support of this kind is a wire splint (Fig. 52), such as Kramer's, or the writer's modification of it.

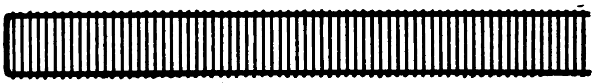

FIG. 52.—Simple wire splint.

If this splint, after being boiled and loosely covered with sterilized gauze, is so adjusted by a gauze bandage that it encircles the extremity without covering the wound-surfaces, it neither interferes with the principles of open-wound treatment nor impedes the action of antiseptic fomentation. The writer may venture to say that his modification of the Kramer wire splint allows much easier adaptation to the curves of the body than the original Kramer splint, consequently it can more advantageously be used to immobilize regions of irregular con-

tour, such as the neck after an operation upon the cervical vertebræ. The treatment described above will often be followed by the conversion of putrid discharges—discolored, muddy, and of an offensive odor—into yellow, inodorous pus.

After the mortified tissues, as well as those that have been injured seriously, are removed, there takes place a copious accumulation of migratory cells and a rapid multiplication of the fixed cells, in consequence of which there forms granulation-tissue containing cells and vessels in abundance. The surface of this kind of tissue is liquefied into so-called *pus bonum ac laudabile.* If removal of dead tissue be not accomplished by the surgeon, this process of liquefaction will separate the healthy from the necrosed tissue.

The richer the vascularity the more rapid is the process of separation. (The spontaneous separation of dead fragments of fasciæ, tendons, and bones would require considerable time.) As soon as the wound-surfaces are free of dead tissue, when the granulations are normal and the local symptoms as well as the general condition of the patient are satisfactory, the wound may again be treated on the previously described dry principles—that is, by packing it with iodoform gauze and protecting it with a sterilized moss splint. This dressing usually does not require to be changed oftener than every sec-

ond or third day. By following the principles of open-wound treatment even malignant œdema, the bacillus of which is most virulent and very resistant, may be treated successfully.

A short time ago the writer discharged from the surgical department of St. Mark's Hospital a patient who entered the institution seven weeks previously with the most alarming symptoms. The history of this man, aged thirty-five years, revealed that internal urethrotomy had been performed by an able surgeon who found the patient with an impermeable stricture. The operation was rapidly followed by the most intense reaction. The penis and the scrotum swelled to an enormous size within twenty-four hours, the prepuce and a considerable portion of the pars pendula being black and blue; the neighboring tissues emitted a fine crepitus when pressed by the finger, and the overlying cutis was raised into blebs filled with red and yellow serum.

The patient presented a typical picture of great prostration and profound septicæmia. His almost constant apathy was interrupted by occasional delirious attacks. The pulse-rate was 146 and the temperature was 102.5° F. The tongue was dry. The emphysematous œdema and the ensuing gangrene naturally pointed to grave infection, to combat which required immediate and heroic means. In consideration of the very weak pulse

and of the apathetic condition of the patient no anæsthetic was given. Deep incisions were made, reaching from the anus across the scrotum, alongside the penis, and up to the left lumbar region. Within the extent of this whole area the cuticle was raised into blebs filled with sanguinolent serum. The incised tissues were partially livid, partially gray and bluish-black, and were infiltrated with foul-smelling, acrid secretions and with the gaseous products of decomposition. Everywhere underneath the emphysematous areas was found a gray-looking, dirty liquid mixed with gaseous bubbles.

Simple incision and evacuation of these liquid elements would not have sufficed to destroy the soil for the microbes, inasmuch as the sloughing tissues, having been so long bathed in putrid fluid, were certainly more or less permeated with it. All the tissues the color of which had undergone great change, especially the gray and blackish-looking fascia and the connective tissue, were removed. A large sharp curette was at first employed for this purpose. After this manipulation, the finger being often employed to explore the pockets in the deeper layers, the surfaces were wiped with gauze mops dipped in an 8 per cent. solution of chloride of zinc. Iodoform gauze loosely folded together was then introduced. Bichloride (1 : 20,000) was poured

into the gauze every hour to keep it continually well moistened. A considerable amount of sterilized gauze saturated with bichloride (1 : 1000) protected the packed wound-surfaces and their vicinity, thoroughly covering the scrotum, the penis, the upper region of both thighs, and the abdomen and the lumbar region on the diseased side. These fomentations of the 1 : 1000 bichloride solution were reapplied every hour.

There was no favorable change in the condition of the patient during the following two days, but at all events the situation did not change for the worse. Above the right trochanter major a red spot, painful to the touch, was observed. An exploratory incision was made immediately after the discovery of this suspicious point. Deep under the fascia was found necrotic tissue bathed in a thin, brownish, putrid fluid. The whole area was treated in the same manner as was the field of the first operation. The following day the pulse fell to 110. It required about a week of repeated removal and elimination of necrotic tissues to convert the wound-surfaces into a region of normal granulation.

Dry treatment was then substituted for the moist fomentations—that is, the wound was packed with dry iodoform gauze and covered with sterilized moss. The dressing was changed once daily during the following week. Later on,

when the discharges diminished, the dressings were renewed only every second or third day.

At the time of the first operation cultures were made with the putrid secretions. After the cultures had been stained with fuchsin there were discovered numerous bacilli connected in a peculiar thread-like fashion, such as is characteristic of the bacilli of malignant œdema (see p. 44). As these micro-organisms are so-called "obligate anaërobic bacilli," it is evident that any kind of occlusive treatment would only have favored their further development, while free access of the inhibiting oxygen of the atmosphere is their main destroying factor. Even if nothing but free incisions had been made and only the necrotic elements had been removed mechanically, it might have been possible to prevent further spreading of the malignant process.

In reference to the use of the *sharp spoon* the writer may be allowed to call attention to its great usefulness, not only on account of its value in removing foul granulations, but also as regards its diagnostic merit. Healthy tissue cannot be scraped away if only the ordinary amount of force is employed. Thus the surgeon may form while scraping a more correct opinion of the vitality of the tissues than he would have been able to do before the foul granulations were removed. Aponeuroses, fasciæ, tendons, etc.

cannot, of course, be removed with the sharp spoon, forceps and scissors being required for this purpose.

In *tubercular processes* the writer regards the open treatment as the ideal method. After resection of a tubercular joint or after extirpation of tubercular glands suturing should only partially be performed, and then only in very large wounds. All the pockets, as a rule, should be loosely but well packed with iodoform gauze. The gauze may remain for five days after operation if there be no particular indication for an earlier change of the dressing.

It often occurs that the wound-surface of a tubercular area is covered by a layer of grayish granulating tissue. This tissue should repeatedly be scraped until the surfaces show a tendency to heal—that is, until the pale, fungous granulations, manifesting no reparative tendencies, have disappeared and the tissues have become firm and healthy. When, on account of local relapse, such repeated operations are required, strict aseptic precautions must be observed, precisely as at the first operation, as tubercular wounds are exceedingly susceptible to infection by pus-microbes.

In the great majority of cases the further course of treatment demonstrates the peculiar antitubercular influence of iodoform, as wounds

treated with it generally heal in a satisfactory manner without forming fistulous tracts. Such influence can be obtained only if the iodoform remains in close contact with the exposed tissues. Further remarks on the antitubercular influence of iodoform are reserved for Section XIV., wherein Aseptic Injections will be discussed.

In laparotomies, especially in *operations upon the intestines*, drainage with iodoform gauze is of the utmost value. If, after resection of the intestine, the whole sutured area is well covered with two strips of iodoform gauze reaching to the mesentery on each side of the intestine, an excellent protection is secured; consequently the sutures are not apt to cut through the edges of the wound, nor is it probable that perforation by a suture will take place. Discharge of feces into the abdominal cavity may thus nearly always be prevented; should it really occur, however, the worst result would be a fecal fistula.

The iodoform strips should be conducted through the abdominal wall to the external surface. The writer suggested[1] fastening prophylactically with two fine sutures the point of the intestinal suture to the abdominal wall,

[1] "Ueber die Behandlung gangränöser Hernien," Langenbeck's *Archiv für Chirurgie*, xxv. Bd., 1880, and "Resection of the Intestine in Gangrenous Hernia," *N. Y. Med. Record*, April 8, 1893.

thus enabling the surgeon to find the suturing point easily in case symptoms of separation should appear and the formation of a fecal fistula should no longer be avoidable. This method does not disturb the healing process, which fact cannot be said of the knot proposed by Jobert.

As W. Rindfleisch has shown by experiments on animals, a sutured intestine generally remains exactly at that point of the abdominal wound where it has been placed. On the basis of this observation he claims that prophylactic sutures are unnecessary. However this may be, the writer deems it safe to use them. They certainly facilitate the search for the suturing point if secondary operations should be necessary.

In cases of *operations on the liver* or *the gall-bladder* the strip of iodoform gauze can seldom be dispensed with. It has the great advantage of absorbing blood, which generally oozes in considerable quantity from wounds inflicted upon these organs. In this event the adhesiveness of iodoform gauze proves of great value, as it adheres to the bleeding surface of the liver, thus preventing hemorrhage into the peritoneal cavity. The gauze may be left in the cavity for from one to two weeks, and as soon as it is extracted rapid occlusion ordinarily takes place, so that the healing process does not require much longer than if primary union had been obtained.

The iodoform-gauze strip should be very long, so that only a single piece will be required. It may be folded together and be pressed against the parenchyma. A small end of the strip may then be led through an interspace left between the sutures of the abdominal wall. In exceptional cases it may be impossible to attach the gauze tightly; it may then be fastened to the parenchyma with a few fine sutures applied to the capsule. As iodoform gauze adapts itself tightly to the serosa, it becomes loosened only when the discharges grow copious. The writer has sometimes kept 10 per cent. iodoform gauze in the abdomen for two weeks, at the expiration of which time it still contained plenty of iodoform, and bacteriological investigations proved it to have remained sterile.

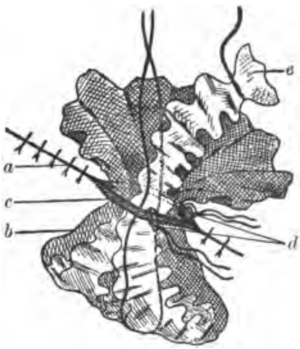

FIG. 53.—Mikulicz's bag: *a*, abdominal sutures; *b*, gauze bag; *c*, abdominal wound; *d*, loops in the abdominal wall; *e*, gauze strip.

Mikulicz advised the use of iodoform gauze in the shape of a *gauze bag* (Fig. 53) as a very efficient means of abdominal drainage. The bag should be at least one inch wide and from six to ten inches long. The bag, filled with a few strips of iodoform gauze, of a width of

about two inches, or with iodoform wicks, should have a string tied to its lower end. After an operation on the *pelvic organs* the bag is placed in the pelvis, across that part requiring drainage; it is then carried over the fundus uteri and led toward the outside of the abdomen, between the sutures in the abdominal wall. The abdominal opening can be separated widely by pulling on loops conducted through each edge of the abdominal wound. Capillary attraction brings the secretion to the surface, where it is absorbed by a thick layer of gauze or, preferably, by sterilized moss-board, the latter at the same time acting as an immobilizing agent (see p. 122, Fig. 34). The strips or the wicks may be removed gradually—that is, some on the day following the operation, and the others a few days later, as the case may require. Wicks are always to be preferred on account of their greater power of absorption. At last the bag itself may be removed by making traction upon the string fastened to the bottom. The great advantage of this method over drainage by rubber and glass tubes is its continuous and automatic action as well as its non-irritation. Ordinary hard drainage-tubes would irritate the intestines, the ends of glass tubes especially exercising great pressure.

Hemorrhage from the large venous sinuses of the brain can seldom be stopped except by packing

the bleeding surfaces with iodoform gauze, which must remain *in situ* for at least one week before firm union of the walls of the sinuses takes place.

In *operations upon the kidneys* the iodoform-gauze tampon prevents retention of discharges in the retro-peritoneal space, the anatomical condition of which favors burrowing of the discharges, an occurrence which in this particular region would nearly always lead to a fatal result.

In areas such as *the rectum*, where the tissues may be contaminated by the constant inundation of infectious material, the iodoform tampon offers the best kind of protection. What, indeed, would surgeons do to cover the wound-surfaces after a resection of the rectum, of the superior maxilla, or of the tongue, without the iodoform-gauze tampon?

Methodical temporary packing with iodoform gauze may be performed in all cases of parenchymatous hemorrhage. After *resections*, in which considerable oozing from the bone-tissues generally takes place during the twenty-four hours following operation, the gauze stops hemorrhage until the capillary vessels are spontaneously occluded by coagulation. Twenty-four to forty-eight hours after such operations, if no evidence of hemorrhage is present and if the wound-surfaces appear normal, the gauze may be removed and the surfaces may be coaptated either

by winding iodoform-gauze strips around them (see p. 195), if the edges of the wound can thus be approximated, or by applying secondary sutures. Iodoform wicks may be used instead of the gauze, on account of their greater power of absorption, just as in peritoneal drainage. Temporary packing with iodoform gauze very often stops hemorrhage from parenchymatous surfaces much more efficaciously than does the Pacquelin cautery. Gauze mops pressed tightly for several minutes against the bleeding surface in operations on parenchymatous surfaces like even that of the liver (compare p. 207) generally arrest the hemorrhage entirely.

Rubber drainage-tubes (comp. pp. 139, 190) should be used only when the employment of gauze is impossible. This is especially the case in large cavities to which free access is impossible or is very difficult, as in pyothorax, for instance (see p. 234). Here the surgeon has to deal with a large cavity the free exposure of which would require such extensive operation as seriously to endanger the patient's life. Were this not the case, thorough packing of the cavity with iodoform gauze would be the proper treatment. Therefore other than the usual means of preventing retention of pus must be employed. To this end the patient should always lie on the diseased side of the thorax, and about every four

hours should be lifted by the feet to compel the pus to flow into the dressing. At a superficial glance this advice may appear rather strange, but clinical experience shows that the observance of this procedure is apt to prevent retention, and it is needless to urge the importance of never allowing stagnation of pus on a wound-surface or, especially, in a cavity. Thus counter-openings, as advised by Kuester, may be avoided. If such cavities are kept wide open, the introduction of a dilating speculum such as advised by the writer is easy and allows free inspection of them.

The writer has refrained from introducing a rubber drainage-tube into the pleural cavity immediately after resection of a rib in pyothorax, as he has witnessed considerable bleeding in consequence. Moreover, the constant respiratory movements of the pleura cause irritation by friction. Therefore, three days after operation the writer introduces a rubber drain, of at least the size of a man's finger, secured by two large safety-pins adjusted in the shape of a cross. It seems that after the pleuræ become accustomed to contact with the atmosphere, and as soon as granulations appear, they bear the irritation well.

Two weeks after operation, on an average, a small drain is introduced and is gradually short-

ened. When the discharges become scanty the drainage-tube may be left out and a small strip of iodoform gauze may be substituted.

Similar principles should govern the introduction of rubber drains after *perineal* or *suprapubic section.* Posture is also very important in such cases. The patient must lie in a position such as will easily allow of spontaneous discharge of the urine. If a rubber drain must be used, it should be surrounded with iodoform gauze whenever this is possible. This procedure applies especially to infected cavities, such as a *bladder* which for months has been occupied by a stone bathed in purulent urine, and which cannot be rendered aseptic in a few minutes after the stone has been extracted (see p. 98). In such a case the combination of iodoform gauze and a rubber drain proves especially valuable.

XII. RENEWAL OF DRESSINGS.

The ideal toward which the modern surgeon strives is primary union; consequently he expects either no discharge in the wounds he makes or only such a small amount of discharge as will not interfere with healing under a single dressing. The less frequently the dressings are changed, the more agreeable it is to the patient. Even the gentlest renewal cannot but cause

some pain and no inconsiderable possibility of secondary infection.

The main indications for change of dressing are: (1) When stitches or drainage-tubes require removal; (2) when secondary hemorrhage occurs; (3) when discharges become so abundant that they cannot be absorbed by the dressings, consequently transuding to the surface; (4) when the dressing is so disturbed that either the protection of the wound becomes imperfect or there is risk of contamination by urine, feces, etc.; (5) when the patient complains of considerable pain; (6) when fever sets in and general symptoms point toward infection; and (7) when there is any doubt as to the character of the fever. In these events clinical experience seldom fails to guide the surgeon properly.

In the majority of cases *removal of the stitches* should take place between the third and seventh days, according to the character of the wound. After delicate *plastic operations on the face* a few sutures may be removed as early as twenty-four hours after operation, while in other operations — for instance, after *laparotomy* — the sutures should remain *in situ* for at least one week— as a rule, from ten to fourteen days. In very *long wounds*, or in those where there is danger of sloughing after removal of the sutures, the stitches should be taken out gradually—that is,

only a few sutures at the place of least tension should be removed at intervals of several days.

Manifestly, when *relaxation-sutures* are used in connection with continuous sutures the interrupted relaxation-sutures must be taken out first. Whenever such sutures cut through the skin they must immediately be removed.

Removal of *interrupted* sutures is performed by seizing one end of the knot with a dissecting forceps and, while slightly drawing upon the knot, cutting through the loop laterally from the line of incision with narrow-bladed scissors. The suture may then be drawn out slowly. It may easily occur that an overlooked particle of the suture remains. This accident should carefully be avoided.

Continuous sutures can much more easily be removed by simply drawing them out after cutting through the exposed portions between the stitch-canals.

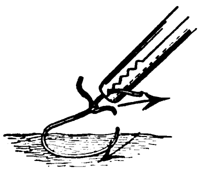

FIG. 54.—Extraction of suture.

The knot (Fig. 54) should always be conducted above the line of incision, so as to prevent separation of the wound-edges, which separation might easily occur if the knot were drawn out toward the opposite side. If tension threatens to separate the lips of the wound, a portion of the sutures should be left in place until the next

removal, when they must be examined thoroughly. If some tension is still present, the sutures may be left until a subsequent change of dressing, otherwise they may be extracted at once. If catgut be used, these procedures are unnecessary, as that part of the suture imbedded in the tissues will be absorbed, so that only the portion of the suture remaining on the surface need be lifted from the skin with forceps. After removing the sutures the wound should be covered with sterilized gauze. Wiping or pressing the wound, irrigation, or other manipulation should be avoided. The modern surgeon is characterized by doing little on the aseptic wound itself, and much around it.

A clean wound healing by first intention should never show the slightest reaction. The edges should be neither reddened nor swollen, nor should any infiltration be present. No pain is ever associated with a wound thus healed. Along the line of union as well as alongside the sutures dried blood and serum are all that will be found. The inner layer only of the gauze protecting the wound-surface should contain a small amount of odorless and dried serum. The first layer of gauze—that is, the one put immediately upon the united wound—may be protected by a second layer of gauze, or, preferably, by sterilized moss-board, which has the

advantage of supporting and immobilizing the parts.

The *secondary dressing* of a wound healed by first intention should be completed over a smaller area than the first dressing, and it should be applied in the same manner as is done immediately after operation, since hardly any further discharge is to be expected. Four or five days later the dressing may again be removed. Such sutures as were left at the time of the latest removal may then be taken out. If the sutures have been removed completely at the first renewal of dressing, there will remain only a narrow line indicating the incision. The dressing may then be dispensed with entirely, or, in case there is found some excoriation of the stitch-canals or of the vicinity of the wound, there may be applied a non-irritating adhesive such as the yellow adhesive plaster.

Wounds which were united, but into the corners of which small drainage-tubes had been inserted, present about the same appearance as those which were sewed up entirely. After operations, as amputatio mammæ, in which buried sutures alone do not suffice to prevent the formation of pockets (possibly beneath the latissimus dorsi and on the anterior surface of the thorax), drainage must be employed. This is best effected by the introduction of *gauze*

drains, but some surgeons prefer very small rubber drains, which must be removed at the first renewal of the dressing. Sterilized-gauze mops should then be kept in readiness to wipe off the serous discharge from the small openings. Wounds of this kind should present as little irritation as those previously described, from which they differ only in discharging more copiously into the gauze. But this discharge has generally dried at the time of the first re-dressing. Sometimes even the gauze drain is dry, or is but slightly moistened with a sero-sanguinolent discharge.

In the absence of infection the wound-canals formed by the drain will be found free of pus, although they may be filled with granulations. After having removed the gauze drain it is advisable to introduce a smaller one, provided the discharge is scanty. Instead of removing the gauze strip, it may be pulled out to a slight extent and be shortened with scissors at the time of the first renewal, and be removed entirely at the second change of the dressing. The same principles apply when, exceptionally, rubber drainage is used.

A gauze drain, when introduced too tightly, is sometimes apt to occlude the canal entirely, thus causing the very retention it is desired to prevent, or, if there are several sinuses, one

or the other may close spontaneously, thereby retaining the fluid wound-products. Mild symptoms of retention then frequently supervene; when they occur, immediate removal of the gauze is indicated. In such a case, as soon as the gauze drain is drawn out with the forceps the retained discharge generally follows. If this should not occur, careful palpation will often indicate the seat of retention, toward which a thin forceps should then be guided to separate the adhesions and to permit the free discharge of the retained fluid. The wound should then be repacked loosely. Occasionally a rubber drain surrounded by gauze may be employed satisfactorily, but only for a few days, as it is expected that after the discharge has lessened the gauze may be substituted again.

In removing sutures in such cases procedures are in order similar to those advised in completely united wounds.

Secondary hemorrhage is another indication for removing the dressing. In wounds which were sewed up entirely secondary hemorrhage is generally due to lack of thoroughness in ligating the vessels, but it may be caused also by the coming away of a ligature due to some movement of the wounded part, or in exceptional cases by the action of the heart in driving out coagula from the end of a divided vessel.

In *open wounds* hemorrhage may be caused by disease of the walls of a vessel or by sloughing or ulceration or septic infection of the wound. Too rapid absorption of catgut ligatures also furnishes a quite frequent source of parenchymatous or capillary hemorrhage. It may also be caused by persistent bleeding which during operation was arrested only temporarily and superficially by tamponing.

In large, deep cavities it may be impossible to apply ligatures to a bleeding artery. Atheromatosis may also render the vessel so brittle that the ligatures cut through instead of constricting it. Exceptionally there may be other reasons that compel the surgeon to resort to the gauze tampon. The dressing must then be applied very tightly, and, if necessary, it may be supported by marine sponges. Naturally, when such conditions are observed during operation, the surgeon should be prepared for secondary hemorrhage after the close of the operation.

Hemorrhage may, however, set in without any perceptible cause, or it may be caused by anything that is likely to increase pressure on the circulation—that is, by coughing, by strangling, or by any other violent effort. It is thus evident that dressings applied under these circumstances, especially to the posterior and most dependent parts of wounds, must be watched with the

utmost care, and after the dressing has been removed a new layer of gauze must be pressed tightly against the wound-surfaces. If this procedure does not prove successful, the gauze tampons introduced immediately after operation must be removed. New strips must now be introduced with a dressing-forceps, by which the gauze can be forced in much more tightly than by any other instrument.

Should blood flow freely from the wound, the sutures must be cut through and the edges of the wound be separated instantly. If hemorrhage takes place from an *extremity*, an Esmarch bandage or some variety of tourniquet should at once be applied (see p. 194). This compression will materially facilitate the procedures afterward to be carried out. The clots filling the cavity are turned out rapidly by wiping the surfaces with gauze mops, so that a clear view of the region may be obtained. If the wound is not too deep nor too irregular, the source of the hemorrhage will soon be discovered. If the source of the hemorrhage be a vessel, it must be tied. If its brittleness or its close attachment to a bone, or any other reason, renders impossible the encircling of the vessel with a ligature, it must be caught up by an artery-forceps, which may be left *in situ*. The wound must then be kept well open and be dressed in this condition. Thor-

ough packing with gauze is often successful after failure to control the bleeding by the above methods or after having passed sutures under the tissues containing the vessel.

After *laparotomy* hemorrhage will only exceptionally be discovered at its onset; consequently the chances for reopening the abdominal cavity are very unfavorable, as the patient will have lost a great amount of blood before the symptoms of internal hemorrhage are well developed. Drainage after laparotomy reveals secondary hemorrhage much more readily and earlier than in cases in which it is omitted. The blood-saturation of the gauze, however, is not necessarily an index of the amount of blood being lost; this is indicated better by the constitutional symptoms, which will be the same as those of any other concealed hemorrhage; their gravity will decide the question as regards reopening the abdomen.

A very frequent indication for the renewal of dressings is that in which *the discharges are so abundant* as to inhibit further absorption. As a rule, after operation on large cavities, where the edges *can be united only partially* or where the surgeon is compelled to leave the wound entirely *open*, according to the principles described in the preceding section, a considerable amount of discharge must be expected. The *first dressing*

must then be changed in two to four days. In such cases, on removing the dressing its outer layers are partially saturated with an odorless and sanguinolent discharge, while the inner layers contain an abundant discharge. The gauze situated directly upon the wound-surfaces generally contains purulent fluid in addition to the sero-sanguinolent liquid.

In that portion of the wound united by sutures such perfect primary union may have been obtained that the sutures may safely be taken out. The gauze, if saturated with the sero-sanguinolent or the suppurative discharge, may then be drawn out with a dressing-forceps, and either be shortened or, if the discharge is abundant, be removed altogether and fresh gauze be substituted. If the principles described in Section XI., on Open-wound Treatment, especially in reference to gauze packing, or to thorough removal of necrotic tissue, were not rigidly observed, it may occur that by drawing the gauze strips forward some retained fluid will be evacuated. This fluid may be mopped into sterilized pus-basins or be taken up by pieces of gauze surrounding the margins of the wound.

After having the whole field wiped clean of discharges another dressing should be applied exactly as that directed after an operation. After the lapse of from three to six days the dressing

must again be renewed if the amount of discharge is sufficiently great to require renewal. Decrease of the discharge, which will then have lost its sero-sanguinolent character and have become entirely purulent, may be expected. The wound-cavities will generally have become much smaller by this time, as they are being filled by granulations exactly as in superficial wounds of the skin.

At the *second change* of the dressings on wounds producing abundant discharge there may be removed all the sutures not taken out at the first removal. A strip of iodoform gauze, smaller than the one used at first, may be introduced loosely into, and be kept in, the cavity, which may be in the same condition now as a common aseptic wound, described above, so that, consequently, it can be treated after the same principles—that is, at intervals of from three to six days the same operation may be repeated until the cavity is occluded by granulations.

If during the after-treatment no micro-organisms have entered the wound-cavity, the discharge becomes serous and scanty and the wound-surfaces are glued together at all the coaptated points. Where no such agglutination takes place granulation tissue will be produced until the cavity is entirely filled with it. Suppuration does not necessarily take place under such conditions,

hence this manner of healing by second intention does not differ materially from direct union by first intention. As a matter of experiment, in resection of a tuberculous knee-joint the writer, after thoroughly packing all cavities with iodoform gauze and after surrounding the whole leg with a large piece of sterilized moss, left the dressing undisturbed for three weeks. After the lapse of this period of time a slight, somewhat odorous discharge was observed on the outer surface of the dressing. When the latter was removed the wound appeared perfectly normal. No microbes could be cultivated from the gauze covering the wound-surface, and no smell except that of iodoform could be detected in this portion of the dressing.

Dressings occasionally produce *dermatoses.* Thus, eczema may result from retained perspiration or from the irritant influence of antiseptics. These eruptions naturally make renewal of the dressings obligatory. The first of the above-mentioned causes may give rise to simple dermatitis, which renders imperative a change of dressing and appropriate local treatment. Intense irritation of the skin may result from employing as a fomentation bichloride of mercury, in which event the substitution of another antiseptic is indicated.

Iodoform (see p. 86) may also produce *eczema,*

especially in individuals who have a peculiar predisposition to this form of dermatitis. The writer's experience at the German Polikinik in New York City shows that about two patients in each hundred are likely to acquire eczema from the use of iodoform. If such patients are carefully watched the eczema seldom acquires such headway that it cannot easily be checked by merely discontinuing the iodoform and substituting sterilized gauze. The writer commonly uses salicylated gauze until the eczema is healed.

The main symptoms indicating the formation of *eczema under a dressing* are burning and itching sensations, which may be so intense that the patient cannot resist the temptation to scratch the part even through the most carefully-adjusted dressing. Manifestly, this act is likely to interfere seriously with asepsis, and it is ample indication for the immediate change of such dressings.

It seems to the writer that most cases of iodoform eczema are generally unrecognized at their earliest stage—a deplorable fact that may lead to serious complications. The text-books do not materially aid in forming a judgment of these eruptions, which, although they generally are of an erythematous character, may assume the papular and urticarial as well as the petechial form, or which may even develop vesicles. The der-

matitis at first is confined to the site of the application of the iodoform, but it may ultimately spread over the whole body.

Most patients acquire eczema only after iodoform has been used for several days or even for weeks. In the case, for instance, of a little boy whose great toe was crushed by an elevator, the attending physician removed the bone-fragments at once and dressed the wound with iodoform powder and gauze. The patient did well for five weeks under this treatment, and the wound had nearly healed, when suddenly the toe and its adjacent parts became red, swollen, and painful. The physician told the parents of the boy that for some unknown reason trouble had arisen in the bone. He thought his treatment had not been sufficiently antiseptic, and he tried to correct this supposed deficiency by applying a quantity of iodoform powder greater than before. Consequently, on the day following the application the whole foot was extensively swollen. The physician thought that he still had not done enough iodoformization, and he then anointed the whole extremity with iodoform vaseline. When, after this last application, the process became diffused over the leg, vesicles appeared, and pain in the groin indicated swelling of the inguinal glands, the physician became frightened and suggested amputation of the toe. This advice, fortunately,

was not followed, but another physician was called in, with whom the writer saw the case in consultation. It caused the writer some trouble to convince his colleague that there was neither an inflammatory process in the bone nor erysipelas, but that the erythematous eruption and the little vesicles were due to the iodoform. The whole treatment for the following three days consisted simply in doing away with the drug, and perfect recovery followed within a few days.

Some cases, moreover, quickly show a most decided and rapidly-spreading eruption, even after minimal quantities only are applied. This rare type the writer used to term the "foudroyant." In cases of this kind the dermatitis may spread over the whole body within a few hours, and it must then be considered quite serious.

Laborers, machinists, etc., whenever injured, should be asked, before applying an iodoform dressing, whether previous injuries were followed by eczema in consequence of using the "yellow powder of offensive odor."

The writer can recall a number of individuals —laborers, machinists, etc., who, on account of the dangerous nature of their business, are exposed to repeated injury—who are aware of their susceptibility to iodoform, and who have acquired such a dread of iodoform eczema that after an accident they implore the surgeon not

to use iodoform in dressing the wound. This idiosyncrasy is sometimes developed to an extraordinary extent. The writer knows of several physicians who are apt to acquire an eczema from merely touching iodoform gauze.

If the dermatitis is so intense that œdema, infiltration, pain, and fever appear, a differentiation from septic erythema or from erysipelas may be difficult. In such a case it should especially be remembered that in erysipelas the margins of the vesicles are wall-like elevations.

Necrosis of the margins of the wound may set in when they are insufficiently nourished in consequence of the cutting off of their blood-supply. (Compare Section XI., on Open-wound Treatment, p. 183.) Such an occurrence is apt to result after plastic operations, amputations, etc., especially if the base of the skin-flap is too narrow or if the sutures are applied so tightly that circulation is impaired by pressure. Diabetes particularly favors this condition. In such a case the sutures must be taken out and the necrotic portions of the wound must be removed. If for any reason the suspicious-looking portions cannot be removed, they should at least be dusted with iodoform or be surrounded by iodoform gauze, which has no disinfecting influence in itself, but which represents a protection apt to prevent further infection of the adjacent wound-surfaces.

Necrotic wound-surfaces are best treated according to the principles enunciated in Section X., on Infected Wounds (p. 172), and no occlusive dressing should be applied. Iodoform gauze is introduced loosely into the cavities and is renewed at least once a day. While, as a general principle, dressings should be changed as rarely as possible, in regard to necrotic wound-surfaces the opposite view must be taken until they have assumed a healthy condition.

A few words regarding *sutures* may here appropriately be added. If the sutures have cut through the skin so that the wound sloughs, they must be removed entirely. It then becomes a matter of choice either to let the wound-cavity heal by granulation or to unite it again by secondary sutures after freshening the surfaces; this latter procedure, however, will only exceptionally be successful. It is only after operations for hare-lip (where partial sloughing is of quite frequent occurrence) that such secondary sutures have rendered the writer valuable service.

Silk or catgut sutures which have not been sterilized thoroughly are not infrequently the sources of infection followed by suppuration in the stitch-canals. Cutting through the sutures favors suppuration, which may take place superficially as well as in the bottom of the cavity when buried sutures are used. If suppuration

is only superficial, the pus may escape spontaneously through the stitch-canals, and consequently the general condition of the patient need not necessarily be impaired. Deep-seated suppurating sutures naturally cause great disturbance of the general condition of the patient, such as fever (up to 103° F.), violent pain, loss of appetite, etc. If the dressing is changed, the tissues will be found reddened and will show extensive infiltration. Collateral œdema is seldom absent, in which case dilatation of the wound-canal with the forceps, or incision, is called for to allow the pus to escape.

If there is much *discharge*, the dressing should be changed at least once a day. If much *inflammation* be present, antiseptic fomentations (preferably of the acetate of aluminum) should be used, after loosely packing the cavities with iodoform gauze, until the inflammatory symptoms have subsided; a dry dressing may then be employed. Sometimes granulations form so abundantly as to require their removal with a sharp curette.

If stasis in circulation takes place, the granulations assume a dark-red or a bluish appearance and finally break down into foul ulcers. This result occurs especially in *varicose ulcers* of the leg, where, instead of normal red granulations, there is found a gray surface covered with

débris and necrotic tissue. Naturally, there is no tendency to the formation of skin-tissue until this more or less infectious material is all removed by scraping and until firm and healthy tissue is reached. The writer found it useful to apply an 8 per cent. chloride-of-zinc solution to such surfaces after curetting. (Compare Section III., on Means of Disinfection, p. 68.)

The writer generally applies either iodoform or sterilized gauze to the surface after the bleeding has been stopped by pressure, the gauze being protected with a large piece of dry sterilized moss secured by a gauze bandage. The dressing is then drenched with a weak solution of bichloride or of acetate of aluminum to make the moss swell, by which means continuous pressure is exerted upon the ulcer; this pressure is sustained by saturating the moss with the liquid every few hours. Pressure in itself being a decided and well-known healing factor, it can thus advantageously be combined with such antiseptic fomentation.

If the extremity is not entirely encircled by the moss, the circulation does not become endangered. When the ulcerated groove begins to fill and the discharge grows scanty an ordinary adhesive plaster and a compressive bandage may be substituted. The same principles of treatment may be followed out at other points, as

well as in similar conditions—for instance, in tuberculous or specific ulcers.

As a rule, such dressings should be performed daily until the granulations assume a healthy appearance. Tuberculous as well as specific ulcers must be scraped repeatedly, and until a satisfactory state is obtained the dressings should be renewed frequently, at least for inspection. Of course, in such cases constitutional treatment should be employed at the same time. If rubber drains are used in large cavities, the tube should gradually be shortened. In cases where—as in pyothorax, for instance (see p. 212)—resection of a rib has been performed, a drainage-tube smaller than the one first used is generally required two weeks after operation; after another week this tube also must be shortened. When the discharge becomes at last serous and scanty the tube may be dispensed with and a small strip of iodoform gauze or a wick be substituted for a day or two.

For the next few days the patient must be watched very carefully. The cavity may be obliterated after twenty-four hours, but very often the union is only superficial, and there occurs retention of pus, which is manifested by an elevation of temperature. The drainage-tube must now be re-introduced, and after a week the shortening of the drainage-tube must be repeated

until, four days after the obliteration of the pus-cavity, no discharge appears and the temperature remains normal. In doubtful cases the grooved director may reveal the presence of retained pus.

The dressing of such large cavities must be changed about twice a day for the first week, later on once a day, and after three weeks it will suffice to change the dressing every second, third, or fourth day.

As has been shown, the open-wound treatment is the treatment *par excellence* for *compound fractures*. In cases where much displacement is present frequent change of dressing is indicated, to permit repeated inspection of the bone-fragments, which, should they be displaced again, may thus easily be returned to their proper places.

For cases in which *union* fails to take place the writer has devised a canaliculated metal splint whose concavity fits the convexity of the bone-fragments, upon which the splint is fastened with a few screws (Fig. 55).

This metal splint when *in situ* embraces the bones to the extent of three-quarters of their periphery, and must then be protected on its exterior surface with iodoform gauze, which must be renewed about once a week. Four weeks after the splint has been screwed on, when at least superficial consolidation may be expected,

an effort to extract the splint is made. If the opening has been kept widely separated by the gauze, the extraction will be easy.

When *pain* is complained of there must be something wrong in the wound, which then requires renewal of the dressing, at all events for exploratory purposes.

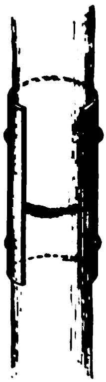

FIG. 55.—Posterior view of Beck's extractable bone-splint *in situ*.

The thermometer is often a good guide in treatment. Elevation of *temperature* demands immediate change of the dressings. Shortly after the removal of the dressing from suppurating wounds a slight elevation of temperature usually results as the natural expression of the irritation of the wound. Therefore, if no constitutional disturbance of any kind be observed, this symptom would be no indication to renew the dressing before the third or fourth day after operation.

The principles of prophylactic disinfection described in Section IV. must be observed when a dressing is renewed, and the preparations should be identical with those made for an operation. Before touching the dressings the hands must be disinfected thoroughly. A nurse should cut through the bandages and the superficial

layers of the gauze with the bandage-scissors. The surgeon, using sterilized forceps, then raises the gauze directly overlying the wound.

It is inexcusable for a surgeon to follow asepsis half-heartedly or to omit precautions on the score of these being unnecessary, even though a wound be septic. If the hands are not disinfected, they may carry pathogenic microbes of greater virulence than those with which the wound was originally infected.

All re-dressing should be done with sterilized instruments, the hands being always kept aseptic. Whenever the hands become contaminated, they must again be disinfected as thoroughly as before. The whole vicinity of the wound should be protected with sterilized towels after the part surrounded by the dressing has been well exposed.

In hospitals the removal of the dressing should be done in a separate room suited to this particular purpose, whenever the condition of the patient will allow him to be transferred. In the surgical ward of a hospital it is convenient to keep patients that require dressings separate from the others. For instance, a laparotomy case should not, as a rule, be contiguous to a case of subcutaneous fracture. It is always advisable to attend aseptic cases before dressing or treating suppurating and infected ones.

When the writer enters the surgical ward of the hospital the first act of the nurse in charge is to prepare boiling water for the small ward sterilizer. While attention is being given to patients not suffering from wounds such as fractures, dislocations, inflammatory processes, etc., preparations are being made for the renewal of the dressings of patients who cannot be transferred to the separate room. The instruments are sterilized at the same time, and are taken directly from the apparatus after the assistants, the nurses, and the writer have disinfected their hands according to the principles of prophylactic disinfection. After use the instruments are replaced in the sterilizer. While an assistant finishes the bandaging the writer again disinfects his hands precisely as before, and the house-staff are required to do likewise. The instruments are again taken from the sterilizer, and another patient's dressings are renewed in the same manner.

There is no excuse for not observing the same precautions in *dispensary* and in *private practice*. In the surgical department of a dispensary the work is greatly facilitated by separating patients with traumatisms from the other patients, and by dressing the former after the latter have been attended to. After a dressing has been removed the instruments used for its renewal are put for

two minutes into boiling soda-solution. They are then taken out by long, sterilized forceps and put into the basin containing the aseptic instruments in sterilized water. This basin was termed by the writer "the sanctum," in order to guard against mistakes on the part of young assistants and nurses in the different designations of the aseptic arrangements. Whatever instrument has been handled must be boiled in the sterilizer before it is regarded worthy of a place among the instruments in this aseptic basin. After each re-dressing the hands must again be disinfected before making another new dressing.

At first the above-mentioned manipulations appear to be cumbrous, but one soon becomes thoroughly familiarized with them through habit.

XIII. TECHNIQUE OF AN ASEPTIC OPERATION.

Whenever time allows, the following series of preparations should precede all important operations. One or more baths should be given the patient to cleanse thoroughly the surface of the whole body. Before this, the patient's urine should be examined with the greatest care as soon as he has entered the hospital. Only soft and easily-digested food should be allowed. If the bowels have not been evacuated, a laxative

must be administered. Where ulcers and eczemas are present, their cure should be effected, if possible, before the operation is performed. In operations upon the stomach, the intestines, or the vagina, irrigations, especially enemas or douches, should first be employed; for preliminary preparations on other parts of the body see Section IV., on Prophylactic Disinfection. In urgent cases, such as a herniotomy for an incarcerated gut, such preparations, unhappily, cannot be made, as life may depend upon immediate operative interference; but the well-trained aseptic operator knows how to adapt himself to the emergency, and will even then, by rigidly carrying out the principles of prophylactic disinfection, especially upon the field of operation, maintain his position as master of the situation.

The surgeon should be surrounded by a staff of well-trained assistants and nurses, to each of whom his or her place must be assigned, and whose duties are well outlined, so that every one does exactly what is ordered, and nothing else. The surgeon should make it a special rule to prepare all the material necessary beforehand, so that during operation everything is ready and within easy reach. The running around of assistants or nurses while an operation is going on is always a symptom of defective knowledge or valuation of surgical asepsis. The surgeon

Exposure of site of operation (necrotomy of tibia) by a cut into the Beck operating-suit.

1 2 3 4

OPERATING-SUITS.—1. Female nurse; 2. Surgeon; 3. Male nurse; 4. Beck's operating-suit for patients.

should personally superintend the necessary preparations, and should not depend too much upon other persons. Therefore his presence at least three-quarters of an hour before the operation is advisable.

It is always important to give the nurses a thorough understanding of the enormous responsibility resting upon them, even if they merely handle a piece of gauze or a needle. They, as well as the surgeon himself, should bathe daily, and they should always wear freshly-washed suits.

In the operating-room there should be kept ready for the surgeon and his staff, as well as for the nurses, a number of sterilized suits (Pl. VIII., Figs. 1, 2, 3) to cover the entire body. These suits should be of some light material, twilled muslin and light linen being useful for the purpose. The sleeves of the coats should cover the upper arm only. During operation the surgeon's suit may happen to come into contact with the clothing of an assistant: if the latter also wears a sterilized coat, no mischief will be done by such contact; if, however, the assistant's coat is not sterilized, pathogenic microbes may settle upon the surgeon's coat, and by further contact contamination of the field of operation may be produced. In private practice, if such suits are not available, sterilized shirts may be substituted.

The head also should be covered with a cap, as in bending over the field of operation it often happens that the heads of the surgeon and his assistant come into contact. Such caps are best sewed to the operating-suit.

Long beards are a disadvantage, and, if their possessors do not feel like sacrificing them on the altar of asepsis, must be protected.

Before the operating-suit is put on, coat, waistcoat, collar, and cuffs should be removed, and care should be taken that the hands do not afterward come into contact with the clothing.

The time required for preparations nowadays generally exceeds that necessary for the operation, and it is true that the urgent necessity of observing the many minute details demanded by asepsis is its most disagreeable feature, but at the same time is the *conditio sine qua non* for success.

Aseptic virtues arise more from a touch of character than from a capacity learned by education. There are some surgeons born aseptic, so to say, and others who will never be able to become thoroughly aseptic, no matter how often they are admonished.

Operative skill, desirable as it is, at the present time does not possess half the degree of importance attaching to this particular feature of character; and it will often be noticed that

the operations of less skilful surgeons, performed with a comparatively small degree of dexterity, are more successful in their final results, provided they are thoroughly aseptic, than the operations of surgeons less scrupulous in their preparations, even though the technical work be performed with the greatest possible elegance.

About one hour before the operation is performed, there are put into the steam sterilizer in the operating-room the gauze, the dressing materials, etc., which, after being sterilized, are placed in metallic boxes standing on glass tables near the operating-table, within easy reach of the surgeon and his assistants. When the materials are not in use they may be covered with pieces of sterilized linen.

In a box or a basin there should be kept ready a large quantity of different-sized gauze mops, which at the beginning of the operation are handed to the surgeon or to his assistant by the attending nurse.

Shortly before anæsthesia is begun, the instruments are selected and put into the boiling soda-solution. Upon removing the instruments from the solution they are deposited in sterilized dishes or bowls, or, if such vessels cannot be obtained, upon sterilized towels placed upon a medium-sized glass table (Fig. 45), easily accessible. Catgut or silk sutures and the materials for drainage

should also be close by, so that they can be handed to the surgeon by the assistant in charge of the instruments. If the writer's metal box for silk or catgut (Fig. 42) is used, it must be surrounded by gauze after being taken from the sterilizer. On another table, standing less near than that for the gauze mops, but within reach of the nurse, are placed several basins, bowls, or plates. One of the vessels should contain the necessary bandages, another the gauze for the dressings, and a third the protective material, such as moss or cotton.

Before the patient is brought into the operating-room—the surgeon and his staff having disinfected their hands according to the principles described in Section IV., and having put on their operating-suits—each assistant has his place assigned and his duties outlined. To one assistant, who stands opposite the operating surgeon, is assigned the duties of sponging, holding the tenacula, and rendering such other assistance as may be required. Another assistant is detailed to pass the instruments. This assistant keeps an accurate list of all the instruments needed in the various operations; *this list must be consulted* before putting the instruments into the sterilizer, to be sure that everything required is well prepared. If the latter assistant does not possess the unlimited confidence of the surgeon, he had better

be dispensed with, the instruments being placed within the surgeon's reach. A third, the most reliable assistant, is charged with the anæsthesia.

After the assistants and the nurses have been inspected by the surgeon and their aseptic condition has been approved, they are ordered to the positions to be occupied during the operation. A table or a chair is then placed about twenty inches behind (to the right of) each assistant and nurse. These tables hold large wash-basins containing hot bichloride solution (1 : 1000–5000), which is to be used under the circumstances previously alluded to (p. 243).

No conversation is to be permitted about the operating-table, so that the surgeon's commands may be audible to all and be promptly obeyed.

Should an instrument, a towel, a bandage, or a dressing drop to the floor, an attendant especially assigned to this duty, and who is regarded as non-aseptic, must at once take up the article and either throw it into a pail or tie about it a piece of bandage or a ribbon to indicate its uselessness for the operation. Instruments or dressings thus vitiated may again be rendered sterile, however, by replacing them in the sterilizer.

Nothing should be required of the *nurses* except to hand to the surgeon the gauze mops, the towels, and the dressing materials, and to attend to the solutions, etc. They should under-

stand that after once being disinfected they must not touch anything that may be contaminated. If a nurse or an attendant has to perform any non-aseptic manipulations—such, for instance, as holding the patient in a certain position or putting away a pus-basin—he should not do any work which may bring him into contact with the wound except he has worn sterilized gloves during such manipulations and has taken them off thereafter.

It is preferable to have an extra room in a hospital for *anæsthetizing* patients (Pl. X., Fig. 2), that they may not witness the necessary preliminary arrangements for the operation. If such a room cannot be had, the patient should be anæsthetized without delay on the operating-table, as it is cruel and apt to excite the patient if he lies conscious on the table where he can see the instruments, etc. Shortly before the anæsthetic is administered the patient should be surrounded with a large sterilized linen bed-sheet or be put into the sterilized operating-suit devised by the writer (Pl. VII.; Pl. VIII., Fig. 4). The writer has found it useful to have these sterilized linen suits, of different sizes, ready for all operations on the body or on the extremities of the patient. The suits are made somewhat similar to a strait-jacket, openings being left in the middle of the abdominal part, in the part over the chest, and

Aseptic herniotomy (cutaneous incision).

2

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1. Immobilizing moss dressing after resection of shoulder ; 2. Anæsthesia-room.

at both wrists; the latter openings are to permit feeling of the pulse. Wherever an incision has to be made there may be cut into the linen jacket a hole which may be sewed up after each use of the dress. In private practice a sheet, if properly applied, would answer the same purpose.

As soon as the patient is partly anæsthetized, he is brought into the operating-room. The operating-table is prepared in the manner described in Section V. Prophylactic disinfection is carried out once more in the most rigorous manner, after the field of operation has been exposed and surrounded by sterilized cloths taken directly from the sterilizer. The surgeon's hands, as well as the operating instruments and the aseptic material, must be prevented from coming into contact with the undisinfected portions of the patient's body in the neighborhood of the field of operation. The instruments in the mean time may be laid upon sterilized trays or towels, thus promoting the work if speed is required.

In operating upon an extremity, if the writer's jacket is not applied, both the extremities should be enveloped in sterilized cloths, otherwise involuntary movements of the patient might bring the undisinfected limb into contact with the disinfected one.

During operation the surgeon, his assistants, and the nurses should wear linen coats (see

page 241). The condition of the coats is of the greatest importance, as nothing except the hand is apt to take up so much infectious material as they do. They should therefore be sterilized thoroughly in steam before the operation. The heads of the surgeon, the assistants, and the nurses should be covered with linen caps.

Instruments can easily be sterilized under the direct control of the operating surgeon, their disinfection requiring but a few minutes; but the materials which must be sterilized in steam require a longer time, especially catgut and gauze mops, which demand a considerable length of time for their sterilization, but which may be preserved in an aseptic state after they have once been sterilized. Reliable druggists should be induced to keep such materials in stock, so that they may be obtained at any moment. But owing to the grave responsibility associated with sterilization, it seems preferable to the writer that the trouble should be taken of personally disinfecting the materials.

Towels as well as *gauze* may be sterilized a few days before the operation, and they may then be preserved in proper metallic boxes until required. This preparation in advance is a great convenience, as by it much time can be saved, but greater security is guaranteed if sterilization is done immediately before the operation.

Better to illustrate the views of the writer, it is advisable to describe in detail the *procedures before and during an operation.* Supposing a radical operation for inguinal hernia is to be performed on a Tuesday at 10 A. M.: The patient is given a warm bath on the previous Sunday, special care being taken with the inguinal region, which is scrubbed and shaved. The scrotum and the inguinal region being also thoroughly scrubbed and shaved, the patient is put in a bed supplied with fresh linen sheets, etc. A poultice of green soap (see p. 96) is then applied to the field of operation, and after having remained there for three hours is scrubbed away again, thus removing as much epithelium as possible. The whole area is then protected with compresses or with a towel saturated with bichloride solution (1 : 1000). On Monday the same procedures are repeated.

At 7 A. M. on Tuesday, the day of operation, a small cup of coffee and a cracker may be allowed the patient. If more nourishment is taken, vomiting may set in, which is apt to interfere seriously with the aseptic state of the field of operation. About 8.30 A. M. there are put into the steam-sterilizer in the operating-room the gauze, the dressing materials, etc., which, after being sterilized, are placed in metallic boxes standing on glass tables near the operating-table, within easy

reach of the surgeon and his assistants. Dishes or bowls, silk, catgut, material for gauze mops, etc. in sufficient quantity are kept ready, the instrument list should be consulted once more, and the operating-table must be prepared. The surgeon, his staff, and the nurses are thoroughly disinfected and are assigned their duties. After everything is prepared and the patient has been put into his jacket the anæsthesia is begun. When the patient is half anæsthetized he is brought upon the operating-table.

The *field of operation* may now be exposed, and the inguinal region, as well as the scrotum, the abdomen, and both thighs, be scrubbed again energetically with soap and warm water. The whole area is then dried with towels and is again washed with alcohol and the bichloride solution.

Sterilized towels to surround the field of operation are then taken from the sterilizer and pinned together with sterilized safety-pins. The penis should also be surrounded with sterilized gauze. In female patients the pubis should be shaved and the vagina be kept packed with sterilized gauze.

After the incision, at least three inches in length, has been made over the hernial tumor, the various structures are carefully divided. Before the sac is reached each bleeding vessel is caught with forceps and is at once ligated. It is

quite customary to wipe a bleeding surface with a sponge in a forcible manner. This is wrong. If a sponge is gently passed along the line of incision for one second and is then withdrawn, the purpose is accomplished and the operating surgeon is least hindered. Considerable capillary hemorrhage must be checked by compressing the surface with pieces of gauze for a greater length of time. The sac is then pinched up by a pair of mouse-tooth forceps, and into it a small opening is made through which a grooved director can be introduced. Further division under the guidance of the director is now made, the surfaces being so separated by tenacula that a thorough inspection may be made.

The sac is now dissected out carefully and is cautiously separated from the cord. After wiping the blood-coagula from the intestine the latter is replaced in the abdominal cavity. The sac is then drawn down, and is either removed after being ligated with catgut or silk or treated in one of the numerous methods prescribed. While the wound is covered and compressed with sterilized gauze the vicinity of the field of operation is thoroughly cleansed, the blood especially being removed; it is advisable to use moist gauze mops for this purpose, and after having dried this area the gauze is removed from the wound. If the slightest hemorrhage be noticed, additional

ligatures must be applied. The wound-surfaces may be united only after they have become perfectly dry. Where coaptation is imperfect there must be used buried sutures, which only exceptionally will be needed after the operation described. After the field of operation has been cleansed again it is covered with sterilized gauze, which should exert more or less pressure.

Excellent immobilization is obtained if a large piece of sterilized moss-board surround the abdomen and the thighs. By splitting the board in the middle of its lower portion (Fig. 34), which is to lie above the perineal region, splints for both thighs can be secured, as shown on page 122. In restless patients the employment of such immobilization is of great importance; it generally answers the purpose so perfectly that plaster of Paris may be dispensed with.

If no disturbance is observed after the operation, the dressing may remain for at least one week; it should then be removed. A part of the sutures also should be removed if silk has been used. A fresh light dressing should be applied, and be allowed to remain for another five or six days, or until perfect recovery is assured.

The preparations described above should be made before any other operation, be it a laparotomy, a resection of a shoulder, or an amputation of the mammæ. Some surgeons think that

they are bound to make such preparations when they intend to perform a laparotomy, but do not observe any such precautions in so-called "minor surgery." *There is no minor surgery.* The same principles stand for the operation of an ingrowing toe-nail as for an abdominal section. It is not so infrequent that death has followed even the simplest surgical operations when they were performed with a disregard of aseptic rules.

XIV. ASEPTIC INJECTION.

A hypodermic syringe is a surgical instrument, and it must be sterilized upon the same principles as other constituents of the surgical armamentarium, lest it may prove a source of serious infection.

Before making an injection the skin of the patient as well as the hands of the surgeon should be rendered clean, exactly as when preparing for any other operation, and the fluid used must be sterilized. Syringe and needles should also be sterilized. Omission of these precautions has frequently caused tubercular, specific, and anthrax infection, and even death by sepsis.

Morphine injections have often been reported as the cause of infection in consequence of the use of a hypodermic syringe which had previously been employed on an erysipelatous

patient. Fränkel recently published two cases of fatal spreading gangrene following subcutaneous injections.

The busy practitioner may probably claim that innumerable injections made without the slightest aseptic precautions have not been followed by evil consequences. This claim must be taken *cum grano salis.* Small abscesses following such injections do not generally come under the observation of the practitioner, mainly because the patient does not call upon him for the treatment of a "little boil," which he deems amenable to home remedies.

Infection, however, occurs not so often as would be expected when one considers the great number of injections made in disregard of aseptic precautions. This is probably due to the rapid absorption of fluids taking place in the cellular tissue, the microbes there finding no conditions favorable for their development. But this fortunate circumstance does not excuse carelessness.

So far as fluids for injections are concerned, only bacteriological investigations can demonstrate their more or less aseptic character.

The drugs most commonly used for injection are morphine, atropine, cocaine, ergotine, pilocarpine, ether, camphor, iodine, alcohol, carbolic acid, mercurial preparations, and solutions or emulsions of iodoform. With the exception of mor-

phine, atropine, ergotine, pilocarpine, and cocaine, all these drugs possess a considerable amount of antiseptic power which is apt to prevent the development and multiplication of micro-organisms, so that they are generally sterile.

Schimmelbusch's repeated examinations of a morphine solution (1 per cent., as generally employed) showed the presence of from two hundred to three hundred microbes to each cubic centimetre. It is therefore advisable to add some antiseptic agent, such as carbolic acid or bichloride, to such solutions as morphine, atropine, ergotine, pilocarpine, and cocaine. Bacteriological investigations prove that the addition of two drops of pure carbolic acid to the ounce of a sterile injection-fluid containing such drugs suffices to keep the solution sterile for a considerable length of time. Alcohol, ether, bichloride, and carbolic acid do not require sterilization.

Few of the drugs named above are of surgical importance so far as their utilization for injections is concerned, and, with the exception of iodoform, they are used only to a limited extent for curative injections into diseased organs.

Regarding the frequent employment of iodoform for injection, the writer deems it necessary to point out its indications and effects, particularly as bacteriological investigations as well as clinical experience have proven its great thera-

peutic value. (Compare Section III., p. 83, and Section XI., p. 207.)

If iodoform is dissolved in ether, no sterilization is required, but if an emulsion is made of glycerin or oil, sterilization should not be omitted. The emulsion will then generally remain sterile for many weeks. The most acceptable method of *sterilizing an emulsion of iodoform* is to fill a bottle and to expose it to the steam of a sterilizer for about an hour. The bottle should not be closed by a stopper, lest pure iodine be set free. If a steam apparatus is not available, the oil and the glass bottle may be boiled separately, and after the completion of this process the iodoform may be added. It has been suggested that iodoform powder be first washed with a solution of bichloride to render it sterile.

The addition of mucilage is not advisable, on account of the great difficulty of thoroughly sterilizing it. Good emulsions, easily kept sterile, can be made with glycerin, and oil of sweet almond will dissolve 5 per cent. of iodoform. The disadvantage of an emulsion or an oily solution is that it cannot be forced through a hypodermic needle. Ethereal solutions do not present this obstacle to their use.

Since it is a recognized fact that at least one person out of every seven dies of some form of tuberculosis, the great importance of antituber-

cular agents is evident. Iodoform undoubtedly possesses antitubercular properties to a marked degree. Bruns, Nauwerck, and Stubenrauch found, after injecting iodoform glycerin into tubercular abscesses (commonly called "cold abscesses"), that the tubercular structures were substituted by firm, normal, vascular tissue. The tubercular area underwent fatty degeneration and necrosis; later on cicatrization took place. These experiments prove that iodoform possesses decided *tuberculocidal* influence.

It is still an open question whether the destruction of the bacilli is exclusively due to the primary effect of iodoform upon tuberculous tissue, as maintained by Troje and Tangl in consequence of their interesting experiments, or whether indirectly the alteration of this tissue, which is a favorable soil for the bacilli, is the cause of their destruction. Practically, however, it makes no difference whether this tuberculocidal influence is a direct or an indirect one.

In tubercular abscesses, such as are often found in joints, for instance, iodoform must be used in comparatively large quantities. Long before the investigations reported above verified this necessity, clinical experience showed clearly that when *small* quantities of iodoform were injected into tubercular abscesses cultures of the bacillus tuberculosis were generally obtained, but the

same evidence could never be furnished when *large* quantities were used.

Stubenrauch endeavored to inoculate animals with tuberculous tissue obtained from iodoformized tubercular abscesses, but in no case did he succeed in producing tuberculosis when he used large quantities of the drug.

In the treatment of tuberculous joints, psoas abscesses, tuberculosis peritonei, etc. iodoform *oil* is especially recommended (compare p. 262). If the joint contains no fluid, the injections will have to be made at different points each time, a needle of large calibre being required. If the different foci contain large masses of cheesy material, or if necrotic bone be present, a cure cannot be effected by this process, but when only fluid, such as pus, is present the chances of success with iodoform injections are more favorable. That the iodoform may come in contact with all surfaces and sinuses of the cavity, the latter must first be emptied.

The antitubercular influence of iodoform is intensified if *hyperæmia* in the tubercular area is produced, the iodoform injections then being made after the principles described below. Hyperæmia seems to produce conditions unfavorable for the development of tuberculosis. Rokitansky has called attention to the fact that congestions of the lungs in persons suffering from

heart disease or from kyphosis are apt to render them immune against tuberculosis pulmonum. Even in patients who, while suffering from well-marked tuberculosis, acquired other pathological conditions which caused congestion of the lungs, perfect recovery from their tuberculosis was observed. The value of *artificial hyperæmia* for therapeutic purposes is therefore obvious. Hyperæmia can best be produced by making a slight constriction above the tubercular focus. Bier advises surrounding the tubercular extremity with linen bandages below the diseased area and applying an Esmarch bandage above it, so as to cause venous stasis in the periphery. As the rubber bandage produces considerable pressure, it is advisable to put a piece of cotton or linen beneath it. Furthermore, it is advisable to change the dressings at least twice a day. The ends of the rubber bandage should be fastened by forceps instead of by making a knot, lest the latter cause excessive compression. Bier's method, however, should be recommended, for obvious reasons, only for hospital practice.

For making injections the writer devised an irrigation trocar (Fig. 56) which materially differs in construction from other trocars, in that it admits the introduction of a second canula after the stylet has been withdrawn. This second canula consists of a double-barrelled tube. Through the

smaller of these tubes, which may be connected with an irrigator, a sterilized liquid can be injected. The larger tube permits the escape of those solid particles which generally may be expected in the pus of such cavities as those al-

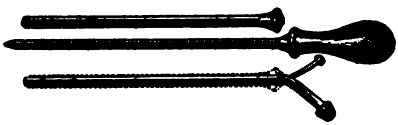

FIG. 56.—Beck's irrigation trocar.

luded to above. Iodoform in glycerin or in oil can then be injected through the larger tube either by an irrigator or by a piston syringe. The advantages of this instrument are that it can easily be rendered sterile in a boiling soda-solution, and that the force of the irrigation stream dislodges solid fragments and carries them off with the recurrent flow. At the same time the force of the water can easily be regulated.

The trocar should be introduced at a distance from the most prominent point of the swelling, the better to conduct it through healthy skin-tissue. The skin should be drawn to one side, so that after withdrawal of the trocar the wound-canal of the deep tissues is not situated immediately beneath the wound in the skin. The opening in the skin must be sealed with iodoform collodion after the operation is completed.

The average dose employed for these injections should be between 4 drachms and 1 ounce, and their strength should be 10 per cent. Injections may be made at intervals of one or two weeks until evidences of satisfactory repair are obtained or until three or four injections show no result, in which event operative interference should no longer be delayed (compare p. 264).

Immobilization is necessary so long as the patient is under treatment. In children moss splints (Fig. 34) are most useful; in adults fenestrated dressings of plaster of Paris are advisable. In spondylitic abscesses orthopædic appliances are indispensable for support.

The results obtained by many authors, notably König, Krause, and Senn, who report cures in 50 per cent. of their cases, and those in the writer's practice within the last few years, in thus treating occluded tubercular abscesses, are so very encouraging that it seems no less than a crime to perform resection of a joint except after iodoformization has failed.

If it is borne in mind that iodoform has undoubtedly cured tuberculosis, and that even simple opening of the abdomen[1]—that is, exposure to atmosphere and light—is apt to produce such metamorphosis in a tubercular nodule as to trans-

[1] "Tubercular and Suppurative Peritonitis," *New York Medical Journal*, April 21, 1894.

form it into innocent scar-tissue, we may be justified in hoping that the near future may bring about such improved methods as will effect a perfect cure of this most dreadful disease.

As shown before, iodoform in oil or in glycerin proves ineffectual as a parenchymatous injection into solid tumors or into glands or goitre; nor will it serve for circumvenous injection in hemorrhoids, varices, or varicocele, as it is impossible to force a sufficient quantity through a small hypodermic needle. An *ethereal* solution is the only available form in such cases, as it will readily pass through the finest needle.

The disadvantageous features of ethereal solutions are—first, intense pain for a minute or two after injection; second, the likelihood of gangrene of the overlying tissues in consequence of over-distention from volatilization of the ether.

The evil effects from injections of ethereal solutions are due not to the iodoform, but to the ether. It cannot be denied that an ounce of ether injected into a cavity, whether or not the ether be mixed with iodoform, is fraught with danger. Gangrene caused by over-distention from the volatilization of ether can be avoided by injecting deeply into the tissues.

Ethereal injections into solid tumors may, as a rule, be made every second or third day. If symptoms of inflammation follow the injection,

fomentations of acetate of aluminum should be applied until the swelling subsides. When but one hypodermic syringeful is employed iodoform intoxication need never be feared.

A fatal termination to a case wherein the ethereal solution of iodoform was employed is reported by Barvis.[1] The patient, a man twenty-four years old, had a cold abscess in the left thoracic region. After evacuating the pus from the cavity Barvis injected over 2 ounces of a saturated ethereal solution of iodoform. Collapse immediately followed, proved fatal, and was attributed by the author to the action of the iodoform. The speedily fatal result, however, makes it appear as if some of the fluid entered the pleural cavity, where the rapidly evaporating ether was quickly absorbed. Had an innocent combination, such as oil, for instance, been combined with the iodoform used in this case, evil results would probably not have supervened.

It may be stated in this connection that suppuration following the use of oleaginous mixtures of iodoform has never occurred in the writer's experience. *Olive oil*, being the mildest and most innocuous constituent, should always be employed when large quantities of the emulsion are required. Glycerin is unobjectionable only

[1] "Du Traitement des Abcès Froids: Intoxication Iodoformique Mortelle," *Archives de Médecine et de Pharmacie*, Tome xvi., No. 8, 1890.

when used in quantities not exceeding an ounce in adults and comparatively less in children.

Absorption is more apt to take place from joints than from so-called "cold abscesses," their membranes generally absorbing slowly. The symptoms of glycerin-intoxication, which occurs much more easily in children than in adults, consist of a slight elevation of the temperature and an acceleration of the pulse. In the urine red blood-corpuscles are always found, and in severe forms cylinders are detected, this indicating great irritation of the kidneys. In spite of these disadvantages, the writer could not be induced to give up the combination of iodoform and glycerin, especially in the treatment of tuberculosis, as the slight inflammatory reaction following the injection of iodoform-glycerin seems to intensify the influence of the iodoform upon the tubercular tissues.

Enlarged glands of the neck generally yield to iodoform-ether injections. This treatment, however, is usually inefficacious in glands whose centres have undergone caseous degeneration. In such cases, if three or four injections, made at intervals of two or three days, prove unsuccessful, extirpation is indicated. It is evident that by following these principles a diagnosis *ex juvantibus et nocentibus* can be made; in other words, that if, after three or four injections, the gland

has not decreased in size, caseous degeneration of the centre of the gland may be assumed, and extirpation should then be delayed no longer.

The same course is advisable in joints, which should be resected if no improvement is obtained after three or four injections of iodoform.

In reference to the treatment of the comparatively rare form of tuberculosis of the peritoneum (compare pp. 85 and 261) the following conclusions may be offered:

1. The injection of an iodoform mixture (1 : 10) into the peritoneal cavity exerts a specific antitubercular action.

2. The diagnosis of tubercular peritonitis in the early stages being possible only in exceptional cases (for instance, in the serous form), and injection of iodoform being useful in other peritonitic processes, it is particularly indicated in all doubtful cases.

Iodoform in powder or in solution is indicated also after laparotomy whenever it is desirable to limit the discharges; furthermore, it appears that absorption of the products of the microbes becomes less virulent in its results by the co-absorption of iodoform.

Ordinary hypodermic syringes can be sterilized only with great difficulty, the inaccessibility of the piston proving a decided obstacle. Robert Koch therefore discards the piston altogether,

substituting a rubber bulb to drive out the contents of the syringe. But by the adoption of this bulb one of the most valuable diagnostic qualities of the syringe—namely, aspiration—is almost entirely lost. Further, the Koch syringe cannot be used for the injection of emulsions. These are points sufficient to prevent the adoption of Koch's syringe in general practice. The most convenient syringes are the asbestos syringes (Fig. 57, *a* and *b*); but all syringes the pistons

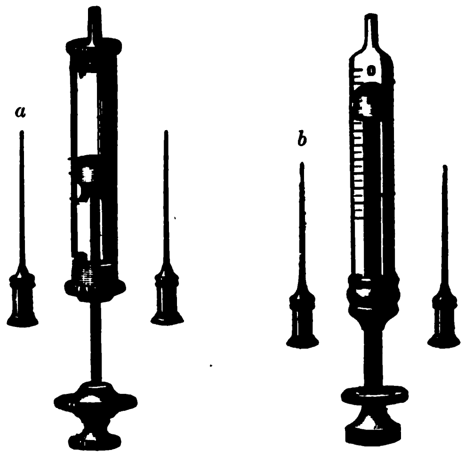

FIG. 57.—*a*, Overlach's syringe; *b*, Meyer's syringe.

of which consist entirely of asbestos work excellently for a certain length of time, but soon prove ineffectual, as the asbestos easily gets out of order. It is evident from the principles empha-

sized in this work that preference should be given to such syringes as can be boiled in a soda-solution. It is a rather unfortunate fact that ordinary hypodermic syringes will not stand the solution without injury. Much, however, can be done by drawing boiling water through them, which is usually not injurious.

The best aseptic syringe known to the writer is the one devised by Schmidt of Berlin (Fig. 58). It is made entirely of metal, so that boiling does not impair its usefulness. The cylinder of the syringe, as well as the hollow piston, is made of nickel alloy. The elastic piston is tightly fitted to the walls of the cylinder and glides freely through it after being anointed with glycerin. The ingenious hypodermic syringe devised by Hotzen of New York is constructed upon similar principles, the only drawback being that a piece of cork must be connected with the piston. The needles can easily be rendered sterile by being boiled in a soda-solution. If they are made of platinum, they can also be sterilized in the flame of an alcohol lamp.

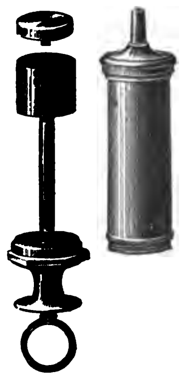

FIG. 58.—Schmidt's aseptic syringe.

XV. ANÆSTHESIA.

The entire civilized world owes an untold debt of gratitude to America for the benefit of many important inventions and discoveries. However great the best of these may be, none can equal in importance to suffering humanity the discovery in 1846, by Dr. W. T. G. Morton of Boston, of the anæsthetic properties of sulphuric ether. This discovery marks an entirely new era in surgery. Before that time painless operations were impossible; thenceforth anæsthesia became a tangible reality throughout the whole world.

The merit of Morton's discovery is not at all impaired by the fact that Dr. James Y. Simpson of Edinburgh a year later discovered chloroform, the great rival of ether. Much time has since been wasted in discussing the relative merits and demerits, advantages and disadvantages, of these two agents. A satisfactory settlement of the question is yet to be hoped for. It is not astonishing that drugs capable of depriving a person of consciousness to the degree of rendering him insensible to pain are not free from danger. Nevertheless, the proper administration of either drug, and careful watching, will reduce the danger to a minimum. The writer, if interrogated by the patient as to the possible dangers of anæsthesia, compares it with a sea-trip, the

dangers of which are known, although ordinarily not feared.

It could hardly be that the administration of either of such powerful drugs as ether and chloroform should not produce some changes in the various organs of the body (especially in the brain, heart, lungs, and kidneys), at least during the time of administration. That there are such changes is evidenced by the fact that in 300 cases of ether anæsthesia occurring in the writer's practice, albumen was found twenty-seven times *after* the anæsthesia, while *before* it not a trace of albumen could be detected. The length of time the ether remains in the system can be inferred by the odor *ex ore*, which sometimes can be noticed so late as three days after operation. In urine passed after an ether anæsthesia a more or less decided smell of ether can always be detected.

We are necessarily quite in the dark as regards the poisonous action of anæsthetics, as most experiments that might reveal the cause cannot be made upon living subjects.

For a long time chloroform was enthusiastically held in favor in Europe, but recently the agitations of French and German surgeons have caused it to be supplanted gradually by ether. The views of surgeons regarding the relative value of chloroform and ether vary widely, but

there can be no doubt that each of these drugs has its advantages and disadvantages.

Ether should not be administered in cases of atheroma of the arteries, nor in renal or pulmonary disease. In kidney diseases it is apt to cause suppression of the urine. In diseases of the respiratory organs, such as asthma, emphysema, bronchitis, etc., the vapor of the ether irritates the bronchi. In operations on the face or in the mouth, in which cases it is impossible to keep the patient constantly anæsthetized, ether is also contraindicated.

There are patients who, although apparently healthy, have a sensitive mucous membrane of the respiratory tract, so that they show a high rate of respiration in ether anæsthesia. They also cough even in deep anæsthesia. In such cases chloroform should be substituted.

In diseases of the heart the administration of chloroform is extremely dangerous; therefore ether should be given in such cases.

The choice of an anæsthetic and its correct administration are of as great importance from the aseptic standpoint as they are on the score of anæsthesia proper. Indeed, the aseptic condition of the patient may be impaired seriously should there be required the manipulations necessary for resuscitation from asphyxia. No surgeon should ever neglect to admonish a patient

regarding abstinence from food the morning the operation is to be performed under anæsthesia. But these admonitions, if not seriously made, are often disregarded in private practice, as is shown by the prodigious quantities of partly-digested food sometimes vomited by private patients during and after anæsthesia. The danger of omitting this precaution is multiform; but primarily it is manifestly a risk to the aseptic condition of the wound, especially when the wound is in the head, the neck, or the chest. It is important, therefore, that the mouth be kept turned from the side on which the wound is situated, lest the vomit contaminate the wound and thwart all aseptic endeavors. It is evident that the very first effort at vomiting must be met by prompt action directed especially to prevent wound-contamination.

The condition of the *inhaler* merits close attention. It may readily become infected in operations upon septic, diphtheritic, and erysipelatous cases. The frame of a chloroform-inhaler should consist of metal, preferably wire, which can be rendered sterile by boiling, and should be so arranged that it can be covered with a few layers of sterilized gauze. For private practice the writer has devised a mask made of two wire frames which can be folded together like a note-book and be carried in the pocket.

For ether anæsthesia any one of the many cones or inhalers may be used, or a simple apparatus may be improvised by folding into a cone a sterilized towel supported by thick paper or pasteboard, and fastening it with safety-pins. The writer has a predilection for the "Clover inhaler," which has the great advantage that the anæsthetizer, by measuring the amount of ether inhaled, is able to regulate its administration. This inhaler also excels by its rapidity in producing anæsthesia.

Before and during ether or chloroform anæsthesia the following rules should be observed:

1. The urine should always be analyzed, especially before the administration of ether, and the heart and lungs must be examined carefully.

2. Foreign bodies, such as false teeth, tobacco, etc., must be taken from the mouth.

3. The clothing must be loosened to prevent even the slightest constriction of the circulation or the respiration.

4. The patient should assume the dorsal decubitus, as syncope may occur in the sitting posture. His head should rest low, on a small pillow, so that it is in line with the body.

5. Before the chloroform-inhaler is applied the lips and the face should be anointed with vaseline as a preventive of irritation and excoriation.

6. The patient should be instructed to close his eyes and to take deep, full, and regular respirations. His attention should also be called to the fact that the first inhalations, although disagreeable, do not subject him to danger. If he shows symptoms of excitement, he should be calmed and encouraged by kind words. Nervous patients sometimes struggle considerably after they have made but one inspiration. This occurs especially under ether. In such cases it is well to drop the mask and to explain that further proceedings will be impossible until the patient remains quiet. Such statements should be made in the kindest manner, otherwise the patient becomes indignant over the lack of sympathy on the part of the anæsthetizer, and it is difficult then to calm his excitement.

7. Chloroform must be administered slowly, and mixed always with a sufficient quantity of air. If ether is given, this precaution is unnecessary and may delay anæsthesia and waste the ether, but in case of cyanosis breaths of pure air should be allowed until the cyanosis has disappeared.

8. The surgeon should not begin an operation until the patient is fully under the influence of the anæsthetic, or "in surgical anæsthesia," which is indicated by paralysis of the palpebral reflex and by relaxation of the voluntary muscles.

9. Good ventilation should be had in the operating-room.

10. Whenever possible, operations by gas-, candle-, or lamp-light should be avoided. Aside from their insufficiency, they are a serious menace, on account of their liability to cause an explosion by igniting the vapors of ether.

11. The safest way of administering chloroform is to let it continuously fall upon the inhaler from a dropping-bottle. A Braatz inhaler (Fig. 59) is a very useful apparatus for the purpose.

FIG. 59.—The Braatz inhaler.

12. The pupils should be watched to ascertain if they are dilated or if they respond to light. Dilatation or their failure to respond to light must be viewed as a sign of approaching danger. Repeated testing of the corneal reflex, however, is not wise, as a much more reliable index for full anæsthesia is represented by the rate and character of the respiration.

13. Careful and permanent control of the pulse and respiration is of the greatest importance. In fact, the respiration needs more attention than the pulse. Quickening of the respiration, as well as weak pulse or respiration, may denote that too much of the anæsthetic has been administered. Loud stertor in chloroform anæsthesia is also an alarming symptom, as it in-

dicates epiglottidean closure of the larynx. If any such disturbance is observed, the anæsthetic must be discontinued instantly. If falling back of the tongue has occluded the larynx, the lower jaw must be pushed forward and the tongue be drawn out with forceps. At the same time the thorax should be elevated, so that the head and neck may fall back. By this manipulation the point of support of the tongue is changed from the posterior pharyngeal wall to the palate, by which procedure the space between the pharynx and the root of the tongue becomes free. Mucus, which is apt to accumulate in the mouth or the throat, especially under ether anæsthesia, must be removed from time to time. This removal is best effected by thrusting into the pharynx a sponge attached to a holder, while the jaws are kept separate with a maxillary separator (Fig. 61).

14. For at least five hours before the operation the patient should eat no solid food, nor should liquid food be allowed later than three hours before the operation. Some brandy and cracked ice may be administered shortly before the operation, or, if the patient is weak, hot brandy or claret may be injected into the rectum.

Habitual drinkers and very nervous individuals should receive a hypodermatic injection of morphine (1/6 to 1/2 grain) twenty to thirty minutes

before the anæsthesia is commenced. Morphine injection should also be performed before operations on the face, the mouth, the pharynx, or the nose, in which cases the operation should be begun the instant perfect anæsthesia is established.

All patients are liable to accident during anæsthesia, despite the most careful precautions. Vomited material may enter the larynx, or the tongue may fall back and press the epiglottis against the entrance to the larynx. Most of these accidents are attributed to cardiac paralysis. Accidents may, however, be due to an overdose of the anæsthetic, as well as to a special pathological condition of the heart, the characteristic signs and symptoms of which condition were not recognized by the surgeon: this condition is vaguely termed an "idiosyncrasy," and its victims may appear to be in perfect health.

Many deaths during or after operations, from what is vaguely termed "shock," are doubtless closely related to the effects of anæsthetics. If all such cases could be analyzed minutely, and if all accidents of this kind were published, the death-rate would be swelled considerably. It is quite human that a surgeon is much more prone to attribute a fatal result to "shock" than to some omission or to the effects or after-effects of an anæsthetic.

If any of the above-described symptoms are

threatened, the administration of the anæsthetic should at once be discontinued, and it should only be continued slightly if the pulse remains weak.

In cases where the functions of the organs of the chest are much impaired by compression through a serous or purulent effusion—in the thorax, for instance—only a few drops of chloroform should be poured upon the inhaler. The same caution should be observed in cases of sepsis and of burns of the third degree, where through the absorption of toxines, which are severe heart-venoms, the heart's action is so much depressed. Patients afflicted with such conditions are, however, not very sensitive to pain, as the toxines exert an anæsthetic influence.

A *limited anæsthesia* frequently leaves an impression only, and not a clear perception, of all the surgical procedures, and frequently it is the nervous dread of these procedures, and not the physical pain itself, which terrifies the most courageous patients. The odor alone of an anæsthetic will sometimes give the patient the agreeable impression of growing, or of being, insensible to pain.

If *respiration* becomes *impaired*, operations may properly be finished without the further administration of the anæsthetic. It is less cruel to trouble the patient and to save his life than to

give him the so-called benefit of full anæsthesia and to risk his life under the pretext of humanity.

The forceps with which the tongue is drawn forward merits some special attention. Whenever the symptoms of respiratory impediment appear and do not yield promptly, the assistant in charge of the anæsthetic should place his fingers behind the angles of the lower jaw and force the jaw forward. If breathing does not then promptly become normal, the tongue must be seized with sterilized forceps and be pulled forward. The jaws of the forceps should be built strongly, and the handles be provided with a catch, so that the instrument cannot slip from the tongue. The writer uses an instrument made especially for this purpose (Fig. 60). In construction it is similar to a Péan forceps, the surfaces of its strongly-built blades being very broad, so as to catch a considerable portion of the tongue. An interspace, to leave room for the non-compressed portion of the tongue, is provided between the catching portion and the joint.

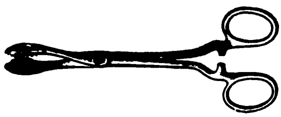

FIG. 60.—Beck's tongue-forceps.

The introduction of the forceps is frequently difficult, as the teeth may be pressed firmly together, in which case the Roser-König mouth-forceps is of great value, as it rapidly separates

Artificial respiration: mechanical heart-impulse and elevation of body with dependent head.

the maxillæ. The writer has devised several modifications of this useful instrument, the most important of which is the establishment of grooves in the triangular mouth-piece of the forceps (Fig. 61, *b*). After this modified separator (Fig. 61, *a*) is introduced it is turned sidewise, and by forcing the grooves into the teeth

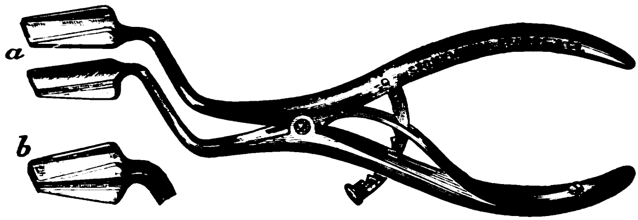

FIG. 61.—Beck's modified maxilla-separator.

the instrument will be prevented from falling out. The removal of mucus is thus rendered easy.

If ordinary means do not suffice to restore breathing, resort must be had to the induction of *artificial respiration*. The writer has found it useful to combine artificial respiration with stimulation of the heart and lowering of the head, as illustrated by Plate XI. After having placed the patient in a position similar to that of Trendelenburg, an assistant grasps the arms at the elbows, carries them outward and upward above the head, and brings them back to the anterior surface of the thorax. This movement should be performed in a rhythmical manner and

about eighteen times per minute. At the same time another assistant thrusts his fingers against the apex of the heart, as if employing a species of massage. While these manipulations are being made camphorated oil and tincture of strophanthus may be injected hypodermatically. Many other valuable methods exist, but it is best to stick to a few, so as to become thoroughly familiarized with them and to be able to carry them out well. It appears to the writer that the procedures above described are the most reliable and are ordinarily sufficient.

If consideration is given to the fact that the essential difference between ether and chloroform is that the first produces an irritant action while the second exercises a depressant one, it becomes clear why chloroform is the more dangerous of the two drugs *during operation.*

Experience has demonstrated that the great majority of deaths under chloroform anæsthesia occur at the preliminary stage, even before the surgeon can use the knife. What is the legal responsibility of an accident of this kind every physician well knows.

The dangers of ether anæsthesia usually set in *during its after-effect.* Not a few persons without the slightest evidence of kidney disease die shortly after an insignificant surgical operation in which ether has been administered. Diffuse

nephritis being found, the fatal outcome is explained. But this is not the only remote danger of ether. Œdema pulmonum, broncho-pneumonia, and collapse, according to a number of reliable surgeons, have frequently followed the administration of ether. Œdema pulmonum and collapse may take place even several hours after the operation, and are then generally not attributed to the anæsthetic. Such occurrences usually not being considered in statistics, it is natural that erroneous conclusions are drawn in reference to the "safety" of ether. On the contrary, as in all diseases of the respiratory tract even the most enthusiastic friends of ether use chloroform anæsthesia, it is just the most unfavorable cases that are reserved for the chloroform. Autopsies are made only exceptionally, therefore an anatomical explanation for the fatal end is rarely found. Autopsies in cases of sudden death after chloroform generally give no explanation. It is supposed that death from chloroform is produced by fatty degeneration of the heart and by an overloading of the blood with carbonic acid. Some physicians maintain that death would be caused by an abundant formation of nitrogen.

As shown previously, many deaths have resulted from the after-effects of ether. An imminent peril being always much more feared than a

remote one, it seems to be natural that the dangers of chloroform appear the more formidable to the practitioner, who dreads a fatal collapse in the operating-room more than he does one in the sick-bed—that is, after some time has elapsed following the operation; therefore he gives preference to ether.

As it stands to-day, *there is no anæsthesia without a possible risk.* The freedom of some physicians, especially beginners, in the administration of anæsthetics in the treatment of trifling injuries and for diagnostic purposes is explainable only on the ground of their ignorance of the danger. Experienced physicians are usually more careful, and avoid anæsthesia whenever they can, their experience and diagnostic talent enabling them frequently to determine pathological conditions by exercising patience and by using combined scientific methods, thus not exposing their patients to any risk in examination. For trifling injuries an anæsthetic should be avoided whenever possible, and local anæsthesia be substituted.

Local anæsthesia is obtained either by the application of cold or by the use of hydrochlorate of cocaine. For minor operations cold can best be obtained by spraying either sulphuric ether or a combination of ether, chloroform, and menthol over the surface with an atomizer for

about two minutes. The integument, after at first becoming reddened, assumes a white color, and finally becomes parchment-like and insensible. The structures beneath the skin are not influenced by this procedure.

Hydrochlorate of cocaine, for the discovery of the local anæsthetizing power of which surgery will for ever be indebted to Carl Koller of New York, is invaluable in operations upon the mucous membranes, as those of the eye, mouth, nose, larynx, vagina, uterus, etc. It can be applied by a swab of cotton in a solution of from 4 to 20 per cent. In operations upon other parts of the body it may be applied hypodermatically in a solution of from 1 to 2 per cent. An Esmarch bandage will prevent cocaine-intoxication and at the same time will increase the anæsthetizing power of the cocaine. The injection, being of itself painful, should always be preceded by the application of an ether spray. A 1 per cent. solution is generally strong enough for hypodermatic purposes. Great care should be taken to inject at different points around the proposed line of incision. A small quantity should be injected into the cellular tissues and into the deeper layers, and a larger quantity, by slowly withdrawing the needle, should be forced directly into the skin, so that the epidermis is gradually raised along the line of the intended incision.

Operations done under local anæsthesia should be performed with special rapidity. The majority of manipulations can just as well be done rapidly as slowly; however, if speed can be exercised only at the expense of thoroughness, rapid manipulation would do more harm than good, and would then be one of the most dangerous, instead of one of the best, attributes of a surgeon.

XVI. ASEPSIS IN PRIVATE PRACTICE.

The prevalent though erroneous supposition among busy practitioners that strict asepsis can be carried out only in hospitals proves a serious obstacle to its principles being always observed in private practice. While in former years the general practitioner was envied by the hospital surgeon because he need not fear infectious diseases being transferred to his patient in a private residence, the general practitioner now envies the hospital surgeon because a well-equipped aseptic hospital offers superior advantages for his surgical cases.

As shown in the previous sections of this work, the main difference between asepsis in a hospital and asepsis in private practice exists only in the greater amount of care and attention to aseptic principles required by the latter. These principles are so simple that it seems

strange that the majority of the profession does not recognize the feasibility with which asepsis may be carried out in private practice.

The main difficulty in convincing general practitioners seems to be that, not being sufficiently familiar with the fundamental principles of asepsis, they dread the commission of errors which might thwart the object in view. They are more familiar with "antiseptic precautions," and therefore declare that they "place more reliance upon antisepsis than upon asepsis, as the splendid results obtained under antiseptic precautions are sufficient proof of their efficacy."

But on a close examination of the so-called "antisepsis" of such colleagues there is encountered great superficiality. Many deem the mere dipping of the fingers into a bichloride solution just before operation as an adequate insurance against infection, being regardless of the condition of their hands, which only a few minutes before may have been in a carcinomatous rectum. Instruments taken from a pocket-case saturated with sweat are put into a carbolic-acid solution to whose percentage no importance is attached. Furthermore, the carbolic acid frequently is undissolved, lying in full strength at the bottom of the vessel, the water not containing a particle of it. A thorough scrubbing of the field of operation is deemed absurd, inasmuch as after the incision is

made irrigation with a strong bichloride solution is credited with the power of washing away all the sins of omission or of any imaginable kind of commission. If, notwithstanding these alleged precautions, it so happens that one or more microbes escape being killed, then the dusting over the wound-surfaces of iodoform powder is expected to destroy the microbes entirely.

The writer has heard similar ideas expressed by colleagues who enjoyed the full confidence of the community. If, to the surprise of the "antiseptic" colleague, sepsis sets in, he emphatically asserts that the strictest antiseptic precautions were taken, and that for some unfortunate reason there must have been some agent in the system predisposing the patient to this fatal course. He has done all he could. He has not only used bichloride, carbolic acid, and iodoform, but he has also looked the latest medical essays over and employed the most recent antiseptic preparations. But, alas! this particular case was "beyond the reach of science."

Had such a colleague but inspected his finger-nails, which perhaps sheltered millions of microbes, representing a graveyard, so to say, his patient might have been "within the reach of science." This assertion would seem to place his entire knowledge of the principles of wound-treatment on a level with that of the laity, among

whom it is known that iodoform, bichloride, and carbolic acid are good antiseptic medicaments.

Only a short time ago the writer met an old practitioner who had been advised to administer intra-uterine douches, and who remarked with great dignity that he was always prepared for intra-uterine cases in carrying a good-sized metal catheter with him. He produced a discolored instrument which looked as if it might have been exhumed at Pompeii. When the writer doubted the aseptic condition of the catheter this learned colleague gave a look of unutterable contempt, put the catheter to his lips, and blew through the instrument to prove that it was still permeable. Thoroughly satisfied with this procedure, he exclaimed, "What objection can be found to this catheter? It is all right. It contains no sanguinolent incrustations!"

Allusion to this instance is made simply to illustrate the deplorable fact that there are some men still oblivious of the advances of the times.

But there is another, happily the larger, class of colleagues professionally developed to a much higher degree, who are always in the vanguard when anything new and rational appears. They are perfectly modern. A fortnight ago they followed antisepsis; to-day they creditably strive for asepsis. They sterilize their dressing material, they boil their instruments, they possess the best

modern aseptic appliances, and they evince a disposition to attain the very best results; but, commendable as these efforts are, they do not go far enough. Many of them place properly-sterilized dressing materials upon an unclean lounge; they rest upon soiled bed-sheets instruments which had been sterilized; their disinfected hands, after having been brought into contact with uncleansed parts of the body, are introduced into the wound; and other similar infractions are committed, thus violating every principle upon which asepsis is based.

No stone, however, should be cast at such men, for they do the best they can. *In short, non-compliance with aseptic rules is simply due to ignorance of them.* The whole profession must be so thoroughly imbued with the principles and so permeated with the practice that the exercise of aseptic rules becomes a mere matter of routine. That we are far from having reached this desirable stage was never more evident to the writer than when, only recently, he saw an eminent surgeon insert his hand, ornamented with several rings, into a human abdomen. If such men thus err, what can be expected of the average practitioner?

When antisepsis was first broached in clinics the country physician ridiculed the new method. The writer remembers hearing an old German "Medi-

cinal-Rath," sixteen years ago, say to his young assistant, who had been educated at Czerny's celebrated clinic at Heidelberg, when offered a brush to clean his fingers: "A brush! what for? All this is nothing but the arrogance of young medical men." But the old counsellor eventually grasped the idea that he could not very well disregard this alleged "arrogance," for the simple reason that the public began to know something of the antiseptic method. The present transition state is somewhat similar to the period of early Listerism, and it is clearly incumbent on surgical specialists to impart all possible instruction on asepsis to general practitioners. Naturally, it will greatly facilitate the introduction of asepsis if its methods are more and more simplified. But it should always be borne in mind that simplicity must not circumscribe the fundamental principles of asepsis.

The manner of execution of aseptic rules is well demonstrated in the preparations for operation in a private dwelling. Every surgeon must be prepared to perform operations *outside the hospital*, and, if necessary, amid the poorest surroundings. He naturally will there encounter a great many more difficulties in keeping up his asepsis than he would at the hospital. But all these difficulties will be overcome by one accustomed in the hospital to thorough asepsis, the

principles of which he will be able to carry out amid the poorest accommodations of the backwoods.

As the surgeon must always be prepared for a call, he should therefore have a set of asepticized surgical appliances ready in a satchel at his office. The writer has found it convenient to preserve the instruments generally required in linen cases, having a separate case for abdominal sections, one for operations upon the bones, one for the uropoietic system, one for tracheotomy, and one for general use (Fig. 62). These linen cases may be rolled up and tied in the middle with a cord after being used. The case designated by the writer for general use contains such instruments as are required in any operation—that is, scalpels, scissors, forceps, retractors, spoons, etc.—and is carried along with the one designated for a special operation. For instance, if a herniotomy is to be performed, the general set is accompanied by the laparotomy set. By keeping these linen cases always ready we may guard against the necessity of sending from the patient's house for a forgotten instrument.

The pocket case devised by the writer actually represents the linen case *en miniature*. With a few buttons it is fastened to a leather case, and it may be carried in a pocket conveniently. By boiling the linen sheet it can easily be rendered sterile.

The instrument-cases can be carried along with the other necessaries in a satchel. The writer uses a satchel of rectangular shape forty

FIG. 62.—Linen instrument-case (for general use).

centimetres long, which gives ample space for the instruments required, as well as for the other necessaries, consisting of a folding sterilizer (Fig. 33), trays (Fig. 23) fitting one into another, gauze and cotton as dressing and sponging material, moss, bandages, silk, catgut, rubber gloves, green soap, brushes, soda, bichloride tablets, ether, chloroform, morphine tablets, and camphorated oil. It will sometimes be convenient to carry the surgeon's coats, towels, sheets, etc. to the house also. Among the utensils the first and most important is the boiler.

FIG. 63.—Simple boiling-pot.

If a physician cannot afford the luxury of a sterilizer, he may order several enamelled pots (Fig. 63) to take its place. A folding stand such as is described on page 110, costing fifty cents, may be carried in a satchel.

Most patients, however, would not object to expending seventy-five cents or a dollar for a "royal baking-pan" (Fig. 64), which, being provided with a small stand, is sufficiently spacious to sterilize both the instruments and the materials for an operation. The brushes for scrubbing the skin-surfaces, if sterilized, can be carried in aseptic towels, as well as the gauze and other dressing material. The ligatures are kept best in one of the metal boxes described on pages 135 and 136. Iodoform gauze may be carried conveniently in a receptacle such as the one devised by Dührssen (Fig. 65). If a pot should not be at hand, it should be remembered that small instruments, such as needles, canulas, bistouries, etc., may be sterilized by boiling them in a tablespoonful of water held above a candle.

FIG. 64.—Baking-pan.

The patient's family should be instructed to keep an abundant supply of boiling water ready in large vessels, and there should be at hand a

sufficient number of linen bed-sheets and plenty of towels. If the tin boilers which are so much *en vogue* are used, they should be scrubbed well with sapolio before being used for surgical purposes. Before being put in use they should be covered with sterilized towels, and the arrangements with the sterilized water should be supervised by an assistant or nurse. It is well to have ready several china pitchers and basins previously scrubbed in the same manner as the tin boilers, and afterward washed with a strong bichloride solution. If basins or bowls cannot be procured for the instruments, they may rest upon sterilized towels.

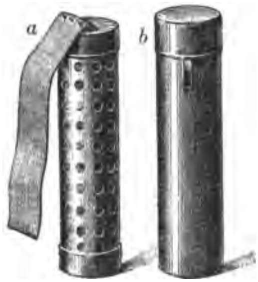

FIG. 65.—*a*, Aseptic receptacle for iodoform gauze; *b*, the case (Dührssen).

The *operating-room in a private dwelling* (compare Section VIII.) should be well lighted. It is wise to send an assistant to the house at least one day before the operation, to see that the room is prepared in accordance with the rules given on page 151. A strong table may be selected for an operating-table. In addition, there should be provided two other tables, of nearly equal size, upon which to place the instruments, the trays, the gauze mops, the silk, and other materials. If the extra tables cannot be

obtained, a number of wooden chairs may be substituted.

Tables and chairs should be scrubbed with soap and boiling water, and with bichloride on the day before the operation. It is also advisable to send a nurse to the patient's home at least twenty-four hours before the operation is to take place, to make the necessary arrangements in the operating-room, and to see that the patient takes a warm bath and is prepared in accordance with the directions given in Section IV. It is a great convenience for the nurse to have an operation blank such as that prepared by Dr. Keen of Philadelphia.[1] On this blank all the necessary preliminary arrangements to be made by the nurse are clearly defined.

It is furthermore necessary to send another assistant to the patient's dwelling at least two hours before the time set for the operation. This assistant should arrange the sterilizer by putting in the soda-solution, lighting the lamp, and depositing the instruments, towels, dressing materials, ligatures, etc. He then renders himself aseptic as described in Section V. Having protected his hands with sterilized gloves, the assistant places in the lightest part of the room the operating-table, and arranges in their proper positions the tables or chairs for the instruments.

[1] Published by W. B. Saunders, Philada.

The instruments, which meanwhile have become sterile, are placed on the tables and chairs, which must first be covered with sterilized towels or with sheets, these tables being so located that the instruments are within easy reach of the operating surgeon.

If much sterilized water is required, it should be brought from the sterilizing utensil in clean pitchers the handles of which are surrounded by sterilized gauze or towels. Within easy reach of the operating surgeon should also stand two basins, one of which should contain sterile water, the other one bichloride.

Only after all the above preparations are finished may the anæsthesia begin. It is preferable that the anæsthetic be administered in an adjoining room. In the meanwhile the assistant should remove his gloves and again disinfect his hands. All the other assistants and the nurses, if called on to perform any non-aseptic manipulations—as, for instance, helping to carry the patient upon the operating-table—should, if possible, wear gloves while doing so. The operating surgeon should also be present at the patient's home as early as possible, so as to control the preliminary arrangements and to give ample time for rendering himself thoroughly aseptic.

When only an ordinary pot can be obtained, the towels, etc. must be boiled in the water; this,

however, necessitates using the materials in a moist state.

After the patient is laid upon a fresh linen bed-sheet, preferably a sterilized one, the field of operation must be scrubbed thoroughly with warm water and soap (compare Section IV., on Prophylactic Disinfection). The area is then dried with towels and is again washed with alcohol and bichloride. Sterilized towels from the sterilizer are now taken to surround the field of operation. Before any object is removed from the sterilizer the surgeon and his assistants, and whoever else participates in any part of the operation, must, of course, have disinfected their hands. When the surgeon and his assistants are prevented from using operating-suits, the latter must be substituted by sterilized bed-sheets or shirts, or at least by one or two sterilized towels fastened over the chest and abdomen by safety-pins. During the entire operation no antiseptic fluid is required. Gauze mops cut into short pieces before sterilization answer every purpose of cleanliness. They may be wrapped in a towel the ends of which are pinned together to protect the mops.

These procedures will doubtless appear strange when first employed by one unaccustomed to asepsis. The feature most likely to disconcert the inexperienced surgeon is the exclusion of

all chemicals during operation. But this initial stage of novelty soon passes off, and every step and detail quickly becomes a matter of salutary habit.

The surgeon should closely scrutinize his every act, and should always bear in mind that no wound, whether clean or otherwise, should ever be treated with a non-disinfected hand. Furthermore, he should not bring into contact with the wound any article or instrument unless it has been sterilized thoroughly. The surgeon should be equally scrupulous in his *private office.* He should imitate the conditions of the aseptic operating-room (see Section VIII.) as much as possible, and should always have boiling water at hand. If he seriously desires to be aseptic, a few days' practice will thoroughly accustom him to the new manipulations. This remark refers especially to repeated prophylactic disinfection of his hands and of all the objects that may come into contact with a wound. This training will teach the avoidance of manipulations which may appear innocent on superficial examination, and yet may cost a human life.

There is no excuse for a surgeon to claim that "the poor circumstances of the patient's surroundings did not permit aseptic precautions." Water, fire, and boiling-pots can everywhere be obtained, so that instruments, silk or common

thread, and dressings can be sterilized. If no dressing material be at hand, old linen may be boiled and substituted. It is true that the dressings are then moist, but nevertheless they are sterile. Freshly-washed and ironed linen, however, is generally sterile, and may be substituted for the gauze.

Public attention should be called to the great importance of the above points, so as to render the aseptic surgeon valuable support. Many persons die from the consequences of having cut their corns with an unclean razor or from having opened a small abscess with a dirty pin. Had they been told that the parts should have been washed carefully and that the razor should have been boiled for a few seconds, they would not have succumbed to the most fell of all destroyers—ignorance. It is a widespread custom to wash wounds with water without being scrupulous as to its source. It may be from a muddy pool or from a dirty vessel, and be spread over the wound to "render it clean." The public should also be instructed that wounds must be disturbed as little as possible, and that only when there is considerable hemorrhage should the bleeding region be pressed for five minutes (or until the arrival of the surgeon) with a towel or a linen compress previously immersed in boiling water.

A most interesting paper, read before the New York Academy of Medicine (May 18, 1894) and published in the *American Medico-Surgical Bulletin* for June 15, 1894, by Surgeon-General Joseph D. Bryant, on "The Fallibility of Human Effort in Aseptic Surgery," illustrates what the writer has before emphasized—namely, that if ninety-nine points of precaution are originally observed, while the hundredth is omitted, the result may be the same as if no precautions whatever had been taken.

Bryant wired a comminuted fracture of the patella uncomplicated by external opening. Although strict aseptic precautions were taken, the joint suppurated and the patient died. The suppuration began superficially in the line of several strands of catgut placed to facilitate drainage. The question then arose as to the cause of the infection. Samples of each of the agents employed in dressing the wound were submitted to the biological scrutiny of Professor Dunham of New York, with negative results in every instance. As the necessary precautions in other respects were believed to have been taken, Bryant was puzzled as to the cause of infection. Finally, before attributing the infection to "unknown influences," he decided to take the class into his confidence. He stated to the student members the sequel to the operation and the

apparent mystery surrounding the wound-infection, at the same time inviting their closest scrutiny and the frank expression of any defect in technique that might be observed in any subsequent operations. This proposition bore immediate fruit in the form of a written communication from a student who modestly suggested that the infection might be due to the fact that the assistant who had plaited the catgut had placed on the table with the other instruments, without first cleansing it, a probe which had been used just before to explore an intestinal sinus.

Bryant correctly says that we should not unduly criticise the momentary forgetfulness of the assistant who thus unconsciously violated an aseptic law, but that we should recall the biblical phrase regarding "motes and beams," and make a retrospective examination of the effects of our own forgetful moments.

All honor to men who do not refrain from criticising their own unfortunate cases. Thus we profit, and in asepsis more than in aught else should be remembered the old sentence in the temple at Delphi: "*Γνῶθι σεαυτόν.*"

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